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Electrical Engineering

February
1932

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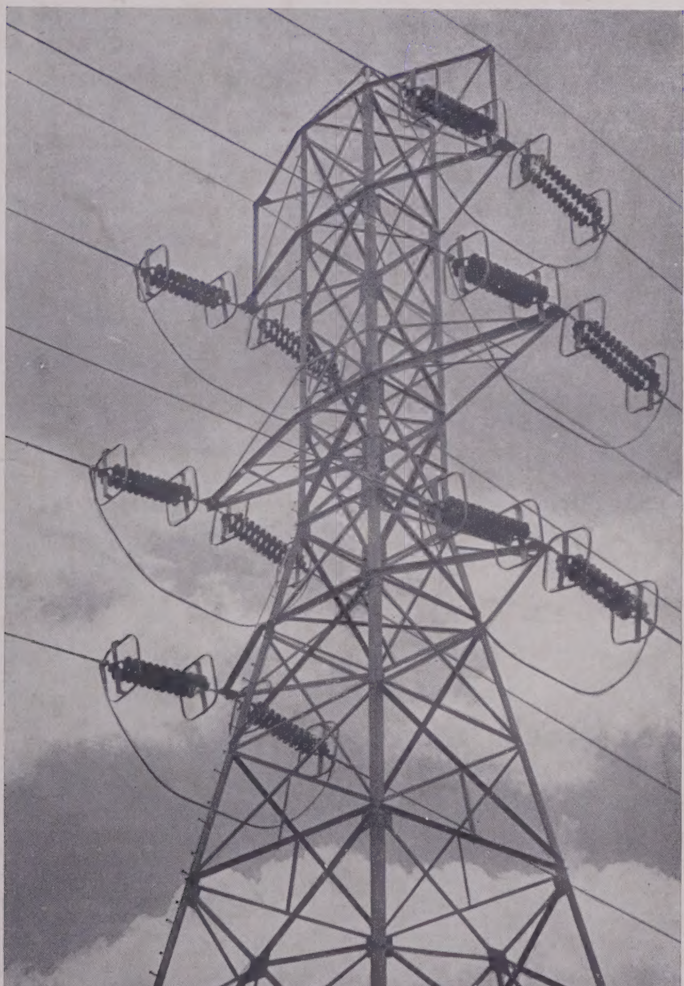

Published Monthly by the
American Institute of Electrical Engineers

FUTURE MEETINGS of the AMERICAN INSTITUTE of ELECTRICAL ENGINEERS

Place	Date	Nature	Manuscript Closing Date
Milwaukee, Wis.	March 14-16, 1932	District Meeting	(Closed)
Providence, R. I.	May 4-7, 1932	District Meeting	(Closed)
Cleveland, Ohio	June 20-24, 1932	Summer Convention	March 20, 1932
Vancouver, B. C.	Aug. 30-Sept. 2, 1932	Pacific Coast Convention	May 30, 1932
Baltimore, Md.	October 10-14, 1932	District Meeting	July 10, 1932
Memphis, Tenn.	November-1932	District Meeting	August-1932

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that such papers may be docketed for consideration by the technical program committee, which formulates programs for all meetings several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author important and helpful information explaining the Institute's rules relating to the preparation of manuscript and illustrations.

Future Meetings of Other Technical Organizations

Society and Nature of Meeting	Place	Date	Correspondent
Am. Physical Society	Cambridge, Mass.	Feb. 25-27	W. L. Severinghaus, Secy., Columbia Univ., New York, N. Y.
Am. Physical Society	Washington, D. C.	Apr. 28-30	W. L. Severinghaus, Secy., Columbia Univ., New York, N. Y.
Am. Waterworks Assn.	Memphis, Tenn.	May 2-6	B. C. Little, Secy., 29 W. 39th St., New York, N. Y.
N.E.L.A. annual convention and exhibit	Atlantic City, N. J.	June 6-10	A. J. Marshall, 420 Lexington Ave., New York, N. Y.
N.E.L.A. No. Cent. Div. Engg. Section	St. Paul, Minn.	Feb. 22-23	J. W. Lapham, 803 Plymouth Bldg., Minneapolis, Minn.
N.E.L.A. Southwestern Div.	Hot Springs, Ark.	Apr. 25-28	A. J. Marshall, 420 Lexington Ave., New York, N. Y.
Pac. Coast Elec. Assn., Engg. Section	Fresno, Calif.	March 9-11	K. I. Dazey, 447 Sutter St., San Francisco, Calif.
Soc. Ind. Engrs., Midwest	St. Louis, Mo.	Apr. 22-23	C. C. Dent, Secy., 205 W. Wacker Dr., Chicago, Ill.
So. Am. Electrotechnical Congress	Buenos Aires, Argentina	July 4-11	R. F. Ascher, Secy., Paseo Co'on 185, Buenos Aires, S. A.

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GREAT Lakes District (No. 5) of the A.I.E.E. meets in March; a tentative technical program has been arranged. *p. 133*

DEFINITION of power system terms, to avoid confusion in stability and interconnection studies, should be reduced to a uniform basis. Proposals of the Institute's special committee on this subject have been submitted. *p. 106-107*

WINTER convention papers not abstracted or otherwise treated in the January issue of ELECTRICAL ENGINEERING are abstracted briefly in this issue. *p. 130-132*

INSTITUTE members were active in the recent annual meeting of the American Engineering Council in Washington, D.C., when three past-presidents were elected to important offices. *p. 137*

MANY factors affect the precipitation efficiency of Cottrell smoke treaters. *p. 93-95*

THE engineer is said to be the man most needed by the world today. *p. 107*

CORRESPONDENCE is invited upon any of the articles appearing in ELECTRICAL ENGINEERING. *p. 138*

WELDING is represented in this issue by the description of a completely self-contained d-c. arc welding generator. *p. 108-111*

PHOTOELECTRIC recorder achieves high sensitivity by not requiring its indicating element to perform recording duties. *p. 114-116*

LONG distance telephony has introduced time problems in voice transmission which are extremely difficult to solve. *p. 89-93*

MANY prizes are awarded annually by the Institute for the best papers presented at conventions and district meetings during the year. *p. 134*

A BIBLIOGRAPHY on transmission line conductor vibration has been prepared under auspices of the A.I.E.E. power transmission and distribution committee. *p. 135*

SHOULD the field switch of a loaded alternator be opened accidentally, tests show that service should be restored by simply reclosing it as soon as possible. *p. 119-120*

HINGED wooden arms on a steel-tower transmission line with eleven insulator units in each string provide line insulation equivalent to from 17 to 23 units on steel arms. *p. 121-128*

FRANK J. Sprague was elected recently to Honorary Membership in the A.I.E.E. as "the outstanding pioneer in the development of electric traction." *p. 139*

INSTABILITY of Conowingo hydro plant was remedied by the installation of high speed relays and circuit breakers, and by changes in the operating set-up. *p. 95-102*

Present Practise in Insulated Power Cables

Essential characteristics and latest developments in power cables are reviewed briefly in this article. Consideration is given to the three principal insulation materials, to different types of cable, and to impregnating compounds. In addition to summarizing present power cable practise in this country, future trends are indicated.

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IN CONSIDERING power cables we naturally think of three types of insulation: rubber, varnished cambric, and paper. There are quite definite limits for each type, governed principally by their electrical and physical characteristics as influenced by economics. The comparative merits of the three types of insulation will be considered first, and then each will be discussed separately. The general characteristics of the three types are presented in Table I in an illustrative manner.

The standard specifications which previously have been generally accepted for rubber compound used on insulated wire prevent manufacturers from using certain well-known and desirable ingredients. These specifications in the past have demanded a chemical test to prove that the compound contains a stated percentage of rubber. Materials which have been largely responsible for the advance of the rubber industry in other lines and for the saving of millions of dollars yearly have been prohibited for use in cables, merely because certain very advantageous ingredients interfere with the chemical tests for percentage of rubber. In recent years it has been realized more and more clearly that great advances could be made if rubber insulation could be judged not by chemical analysis of ingredients but by tests which show its performance and give an indication of its length of life.

While probably no tests will prove definitely that a certain compound will have a life of ten years or thirty years, tests have been developed which so closely simulate service conditions that they are entirely adequate to prove that one insulation will have a much longer life than another. These tests, are: first, the Geer test in which test samples are suspended in an oven at 158 deg. fahr. and hot fresh air is allowed to circulate; and second, the oxygen-bomb test, usually considered superior to the Geer test, and based on the fact that deterioration in rubber compound usually is due to oxidation. The samples are placed in a bomb filled with oxygen under 300-lb. pressure at 158 deg. fahr. In both the Geer and bomb tests, samples are taken out and are tested for tensile strength and elongation, the resulting values being plotted against time. A third and valuable form of test is the ozone test, in which rubber-insulated conductors in various forms are placed near a grounded metal plate and a sufficiently high voltage applied to cause the breakdown of the air external to the rubber, thus exposing the insulation to the action of ozone.

Table I—Characteristics of Cable Insulation

	Rubber	Varnished cambric	Paper
Moisture resistance	Very high	Fair	Hygroscopic
Max. allowable temperature	60 deg. cent.	75 deg. cent.	85 deg. cent.
Can be bent to	6 diam.	8 diam.	12 diam.
Affected by corona or ionization	Yes	Resists	Resists
Life	Fair	Long	Long
Power factor 60 deg. cent.	5%	6%	1%
Installation and jointing	Very easy	Easy	Requires care
Can be used non-leaded	Yes	Yes (indoors)	No
Dielectric strength in volts/mil for 1 hr	250	250	400
Standard test voltages in volts/mil	70	125	200
Specific inductive capacity	3.5 to 6	3.5 to 6	3 to 4

Typical curves obtained by the oxygen bomb test are shown in Fig. 1. It will be seen that the standard specification of the A.R.A gives a compound which deteriorates rapidly, while a performance compound containing 30 per cent rubber judged by the performance standard rather than by chemical tests is affected very little, and a special heat-resisting stock is hardly changed at all. The N.E.L.A. and the A.S.T.M. lately have adopted tentative standards for judging rubber compounds by performance tests rather than by purely chemical tests. These undoubtedly will make future progress more rapid and will result in a large economic saving to the electrical industry.

Written especially for ELECTRICAL ENGINEERING and based upon a talk presented before the power group of the Institute's New York Section. *Not published in pamphlet form.*

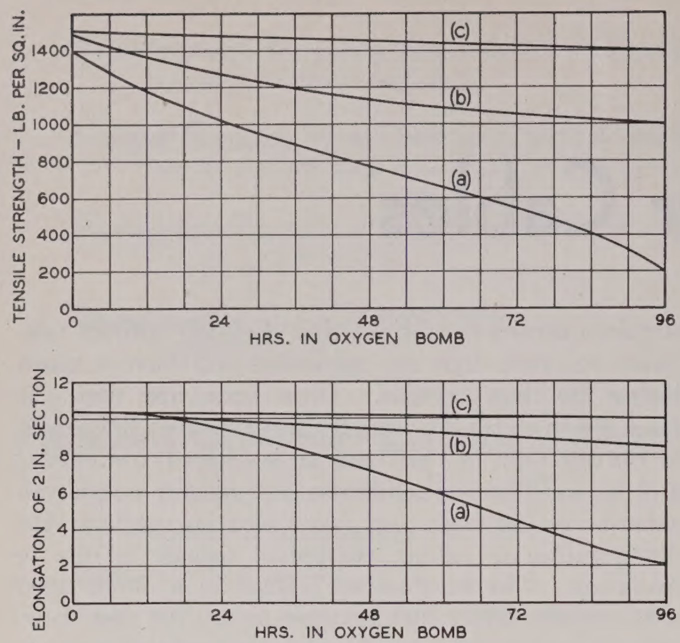

Fig. 1. Aging characteristics of rubber compounds as shown by the oxygen bomb test performed at 158 deg. fahr. and 300-lb. pressure

(a) A compound containing 30 per cent rubber as shown by the chemical tests of the American Railway Association
(b) A compound containing 30 per cent rubber, but in which the percentage of rubber cannot be checked by chemical tests
(c) Compound same as (b) except that it has been specially compounded to meet high temperature conditions

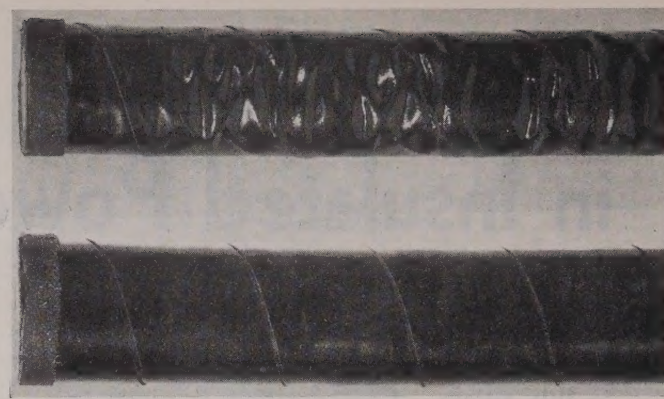

Fig. 2. Butted construction (below) of applying varnished cambric tape has characteristics superior to overlapped construction (above)

Table II—Insulation Recommended for Station Cables

Nominal system voltage		Preferred insulation for non-leaded cables	
From	To	First	Second
0....	600 ..	Rubber...........	
601....	4,000 ..	Rubber...........	Varnished cambric
4,001....	13,200 ..	Varnished cambric.	Rubber
13,201....	17,000*..	Varnished cambric.	Paper (lead-covered)

*At voltages higher than 17,000 volts, paper-insulated lead-covered cables should be used.

Varnished cambric has a higher dielectric loss than now obtainable with paper, and due to the method of manufacture, contains some air and moisture. The present trend is toward a reduction in the dielectric loss as well as a different application of the tapes so that wrinkles and voids will be largely eliminated. Many years ago it was found necessary in the manufacture of paper cable to apply the paper tapes so that they butted instead of overlapped. Only recently this has been used on varnished cambric. These two types of tape application are shown in Fig. 2, except for the cases of small sizes of conductor and thin walls, the freedom from wrinkles in the butted construction increases the dielectric strength, greatly improves the ionization characteristics, and is undoubtedly an important step in the direction of improvement of varnished cambric cables.

Varnished cambric when leaded is more costly than paper and rarely is used for underground transmission. For station work, however, it is sufficiently resistant to moisture to operate without a lead sheath and terminals, and thus varnished cambric braided cable often has considerable advantage in cost over other forms. Table II shows recommended types of insulation for station cables.

Impregnated-paper insulated cable is used universally for underground transmission of large blocks of power and for high voltage work. It is not only the least expensive type of cable available for this purpose, but also it has by far the highest dielectric strength, longest life, and greatest reliability. For voltages of 33 kv. and over, it is at present the only type which can be used successfully and economically.

Up to a few years ago, multi-conductor cables were mostly of the belted type, a cross-section of which is shown on the left in Fig. 3. These cables proved fairly satisfactory for voltages up to 26 kv.; however, when it was attempted to use this construction at 33 kv., the belted cable was found entirely inadequate unless very heavy walls of insulation were used. It was proved that the weakness was not the insulation proper but the filler spaces. The filler material is inherently weaker than the conductor insulation, and furthermore, the stresses in the outer layers of conductor insulation have a component of force parallel to the layers, by far the weakest direction. Another weakness was that during motion of the cables, separation took place between insulated conductors, creating voids in the filler spaces. All these effects resulted in charring and burning of the filler spaces and outer layers of conductor insulation, often resulting in failure of the cable.

The solution to all these difficulties is the type *H* cable, so named from its inventor, Martin Hochstadter. The three-conductor type *H* cable is shown in the middle in Fig. 3. This design with a metal foil enclosing the conductor insulation prevents all the troubles of the belted cable because the filler spaces are completely shielded from electrical stress. Furthermore, the type

H cable has a considerable advantage in current-carrying capacity. In the first place, being electrically equivalent to three single-conductor cables under a lead sheath, it can be operated at the higher temperatures permissible for single-conductor cables. Secondly, copper has about three thousand times the thermal conductivity of paper. Copper foil therefore is very effective in conducting heat out to the lead, resulting in a reduced temperature rise of the copper above lead. The gain due to higher permissible temperature is independent of installation conditions and increases with working voltage. The increased current-carrying capacity for underground and aerial cables is shown graphically in Fig. 4.

The remarkable performance of type *H* cable has led to its practically complete adoption for voltages 20 kv. and higher in this country and abroad; in fact, it is in very general use down to and including generator voltages on the order of 11 kv. Due to the elimination of filler stresses, it is now possible to make multi-conductor cables for any voltage except where questions of diameter impose a limitation.

Type *H* construction is used also on single-conductor high-voltage cables, metallized paper being applied to the surface of the insulation as shown on the right in Fig. 3. The function of the metallized paper is to shield from all electrical stress, any voids which may occur between insulation and lead, such voids being formed when the cable is bent or when the lead sheath is stretched by the expansion of the compound under load cycles.

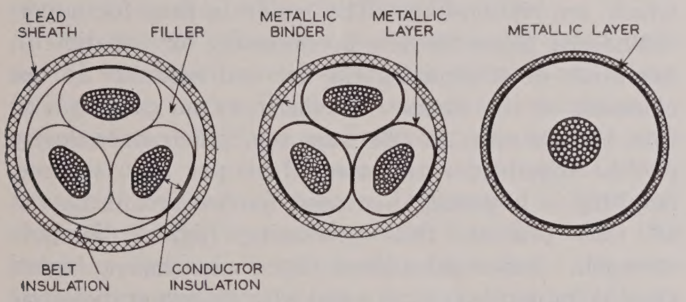

Fig. 3. Cross-sections of belted cable (left), multi-conductor type H cable (middle) and single-conductor type H cable (right)

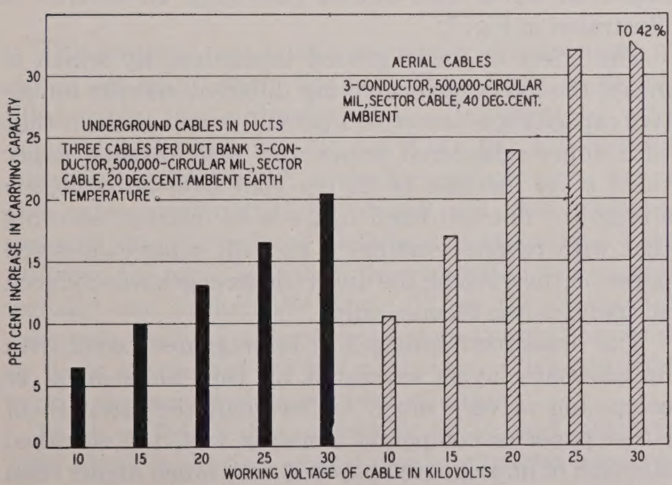

Fig. 4. Increase in carrying capacity of type H over belted cables

A-C. Resistance of Three-Conductor Cable

Due to the recent use of larger and larger sizes of conductor in three-conductor cables up to 750,000 cir. mils for instance or even 1,000,000 cir. mils, it has become increasingly important to know accurately the effective a-c. resistance and reactance of such cables. These cables have additional losses due to skin effect, proximity effect, losses in the metallic binder tape, and in the lead sheath. The problem of these extra losses is important from the loss standpoint and from the standpoint of paralleling cables; it is being studied cooperatively by the Insulated Power Cable Engineers Association, some utilities, and the Electrical Testing Laboratories.

Some theoretical calculations made of losses, and which are quite close to actual measured values are shown in Fig. 5. It will be noted that the increase of a-c. effective resistance is considerable for the larger sizes. At first it was thought that the extra losses were in the magnetic steel binder tape used in type *H* cable. While final results have not yet been obtained and while

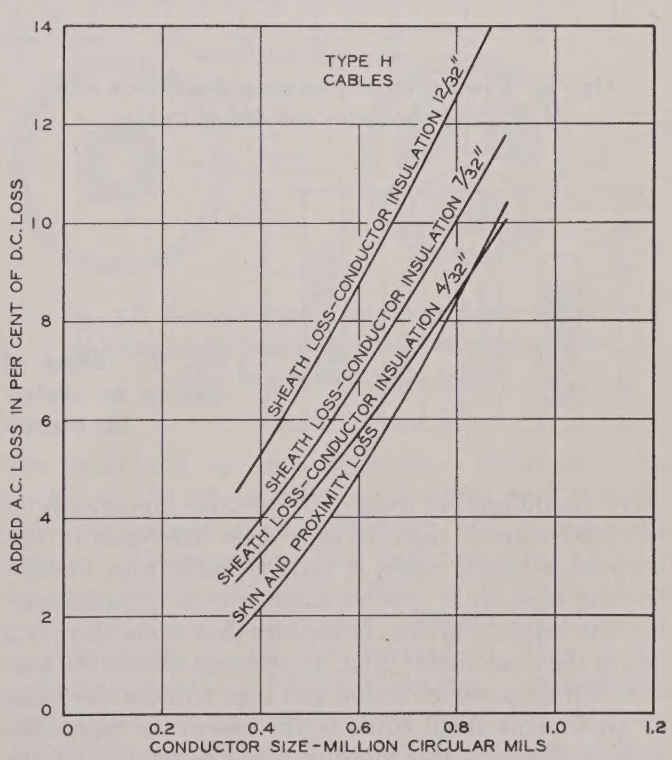

Fig. 5. Added a-c. loss in three-conductor cables at 60 cycles and 20 deg. cent. Sector cable with 9/64-in. lead and non-magnetic binder tape

Added a-c. loss = skin and proximity loss + sheath loss

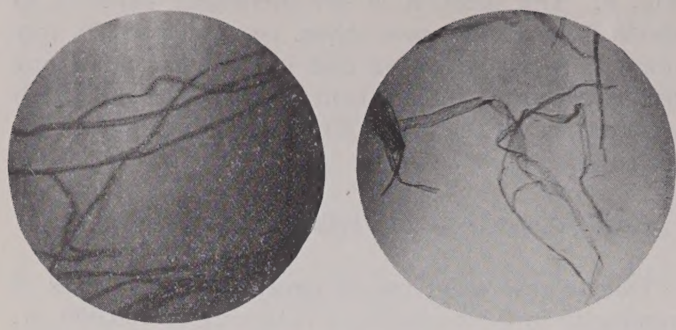

Fig. 6. Photomicrographs of fibers from ordinary wood pulp paper (left) and super-calendered wood pulp paper (right)

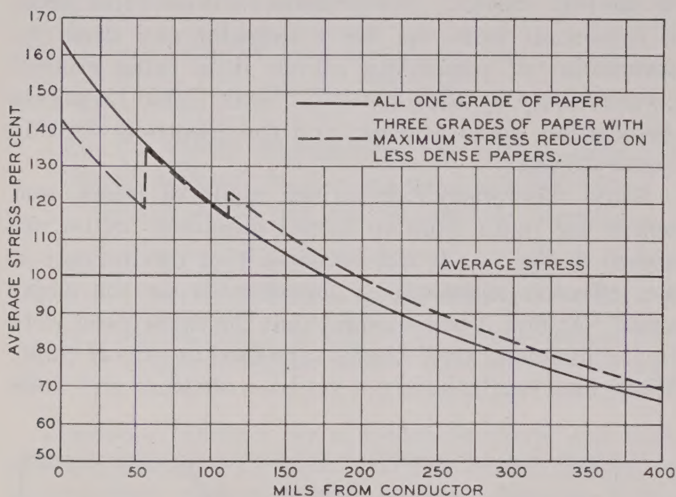

Fig. 7. Effect of grading on stress distribution with 4/0 round conductor and 406-mil paper

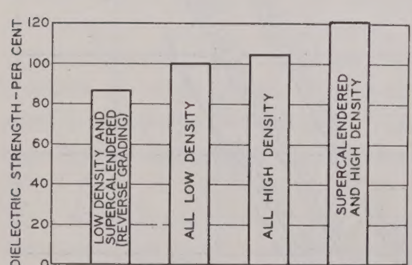

Fig. 8. Effect of grading on dielectric strength

there are differences from cable to cable, apparently at full load current there is very little difference in loss between a belted cable, a type *H* cable with a steel-binding tape, or a type *H* cable with a non-magnetic binding tape. Further, it appears that while there is a loss in the steel binder tape, its presence shields the lead sheath from some induction and thus reduces the losses by an amount about equal to the loss in the tape, thus making the total loss more or less independent of the type of construction.

Possibly the most important result of the study has been the emphasis that there is a considerable increase of reactance due to magnetic binder tape. The reactance of cables is so low that the increase is not of great importance in itself, but it is very important when studying the question of parallel operation of cables. The increased reactance ranges from an increase of 25 per cent in a three-conductor 350,000 cir. mil cable down to about 15 per cent for a three-conductor 1,000,000 cir. mil cable.

Materials

For many years most cable specifications required the use of manila rope paper, *i. e.*, paper made from fibers obtained from used manila rope. In recent years, however, wood pulp paper made by the sulphate process has been almost universally used in paper cable. It is usually made from Swedish pulp. This resulted in a great economy, and is responsible partially for the great increase in dielectric strength that has been evident in paper cables.

As the name implies super-calendered paper is paper which has been subjected to an additional calendering process which results in very dense paper having about 15 per cent higher dielectric strength and 30 per cent higher mechanical strength. Photomicrographs of ordinary and super-calendered fibers are shown in Fig. 6. The central channels apparent in the fibers of ordinary paper are not present in the super-calendered fibers, which are ribbon-like. The result is that for super-calendered paper there is no necessity for the difficult operation of eliminating the air and moisture in the channels of the fibers. Furthermore as can be seen from the pictures, the fibers are very much more closely packed together, with more fibers per unit volume, resulting in a greatly increased barrier action against all ions present, thus producing higher dielectric strength. Super-calendered paper also has a higher specific inductive capacity and with its higher dielectric strength, it is the ideal material to place next to the conductor where the stress is highest; it thus becomes possible to grade the insulation so that the maximum stress near the conductor is materially reduced. The improved stress distribution that may be secured is illustrated in Fig. 7.

The effect of using graded insulation, by which is meant the use of papers having different specific inductive capacities, is shown in Fig. 8. It will be seen that with super-calendered paper and high density paper there is an increase of 22 per cent over-all dielectric strength. The left-hand figure is of interest, showing that with reverse grading, *i. e.*, with super-calendered paper on the outside, the dielectric strength was reduced actually, as it is theoretically.

The breakdown strength of impregnated paper with its alternate layers separated by thin films of oil or compound is very much higher than the strength of either paper or compound alone; in fact, the electrical strength of impregnated paper is very much higher than that of any other materials available as cable insulation. In the early days, very viscous compounds composed of mixtures of rosin and rosin oil ordinarily were used.

These early materials, however, had high dielectric losses, and the next step was the use of mineral materials such as petrolatum, mixed with rosin. The insistent demand for still lower losses soon led to compounds of the nature of petrolatum thinned with transformer oil. Such compounds have low losses but some of them were not sufficiently stable chemically under the severe requirements of service. Mineral oils of the cylinder oil type which can be mixed with rosin or rosin oil and which have losses even lower than those obtained with the 100 per cent mineral compounds now are available.

There always has been more or less diversity of opinion as to relative merit of straight mineral oil or a mixture of mineral with rosin or rosin oil. The laboratories of the company with which the writer is associated have proved that high-grade rosin or rosin oil acts as an anti-oxidant when added to mineral oil in the proper proportion, mixed, and aged at the proper temperature. Rosin increases the stability of the resultant compound when subjected to dielectric stresses and its resistance to the so-called "wax formation" is greatly increased. It is of course necessary to select the proper grade of mineral as well as rosin oil so that the latter will remain in solution in the former. The photomicrographs in Fig. 9 show the appearance of proper and improper mixtures; the large undissolved crystals of rosin in the photomicrograph on the right are to be noted.

The effect of differences in impregnating compounds on the voltage-time characteristics of cable are shown in Fig. 10. Curve X is for a compound containing no rosin or rosin oil; it was used several years ago but with great success. Curve Y is made on cable insulated with a special mineral-oil rosin-oil compound. Note the slope of the curves as well as the fact that after two hours application of voltage they have about the same breakdown strength, whereas for long-time tests, there is a great gain for the one compound. Other things being equal, the superiority of compound Y is quite obvious.

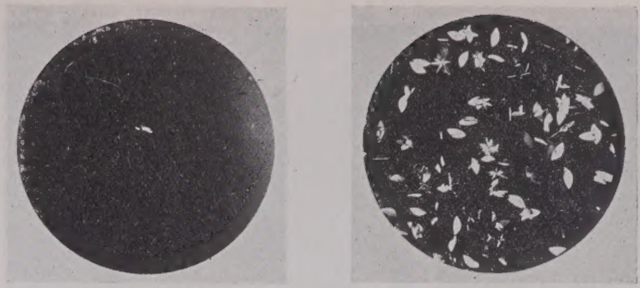

Fig. 9. Photomicrographs of different mixtures of impregnating compound

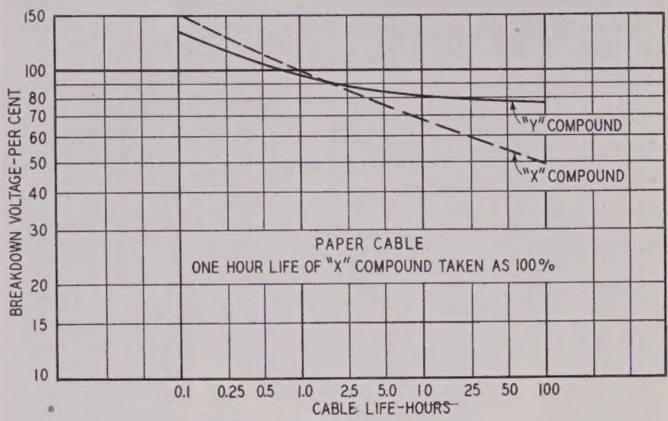

Fig. 10. Effect of different impregnating compounds on cable voltage-time characteristics

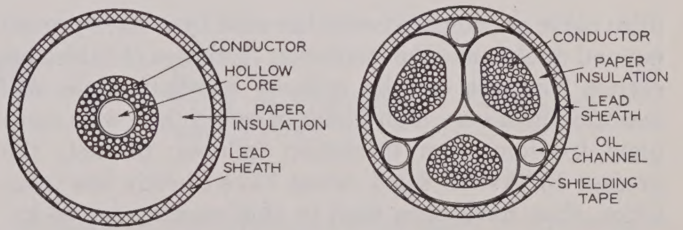

Fig. 11. Cross-section of single-conductor 132-kv. oil filled cable (left) and of three conductor 33-kv. type H oil-filled cable (right)

Oil Filled Cable

The greatest and most spectacular development of cables for many years has been the advent of the oil filled cable. An ordinary cable is impregnated with what might be called an oil, but it is a fairly viscous oil which is not fluid at all operating temperatures, nor is the cable constructed to permit oil flow. Consequently, due to the large coefficient of expansion of the oil when the cable is heated, the compound will expand radially and stretch the lead. When the compound contracts, the lead will not contract and partial vacuums or voids are created in the insulation. This phenomenon is the main enemy of cable insulation.

In an oil filled cable, a thinner oil is used which is fluid at all operating temperatures; channels are provided for oil flow. When the cable is heated by load and the oil expands, the oil can flow lengthwise of the cable through the channel or channels of the cable into the joints and out into reservoirs. When the cable cools and the oil contracts, it is forced back into the cable by pressure on the reservoirs, and no voids are created. Cross-sections are shown in Fig. 11 of a single-conductor 132-kv. oil filled cable and a three-conductor 33-kv. oil filled cable. The subject of modern oil filled cable practise was covered in three papers recently presented before the Institute. Articles based upon these were published in Electrical Engineering for November 1931, a follows: "Economics of High Voltage Cable," by D. W. Roper, p. 874-8; "Layout of Oil Filled Cable Systems" by G. B. Shanklin and F. H. Buller, p. 878-80; and "Accessories for Oil Filled Cable" by R. W. Atkinson and D. M. Simmons, p. 880-2.

The practical operating results obtained with oil

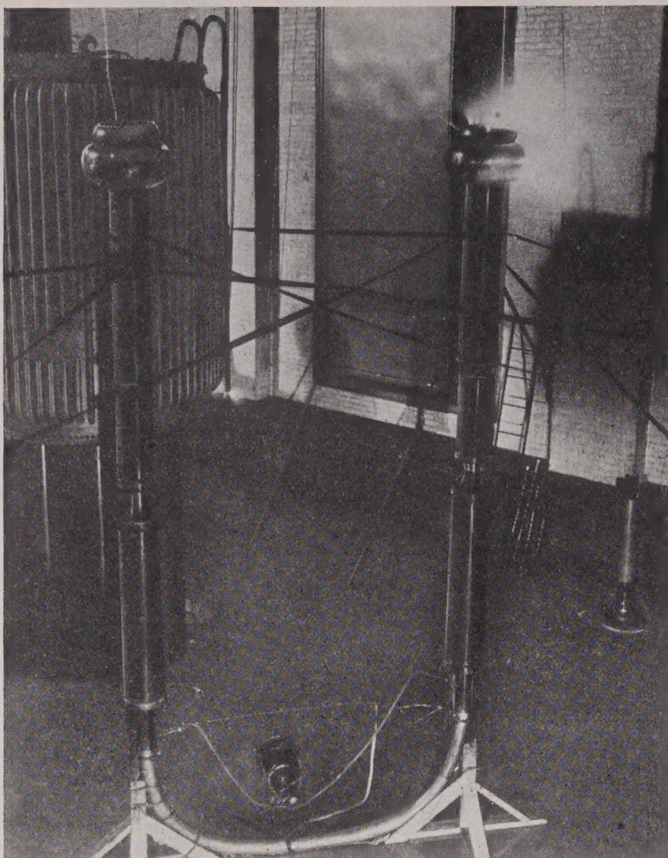

Fig. 12. Breakdown test on 220-kv. cable

filled cable as compared with the solid type have proved beyond doubt that the insulation thickness of cables for certain voltages can be reduced one-half while still maintaining a very high factor of safety, and with complete freedom from insulation failures; in fact, the present 132-kv. oil filled cables have slightly less insulation than have been used in this country for 66-kv. cable of the ordinary type. Furthermore, for the past year the Commonwealth Edison Co. of Chicago has had experimental lengths in operation at 132 kv. which have slightly less than 13/32 in. insulation thickness, or the same thickness as standard for 35-kv. cables of the ordinary type. These lengths have had load cycles heating the cable up to 70 deg. cent., and have performed even better than expected; in fact, the power factor and ionization which have been periodically measured have improved in service.

While at the present time there is no 220-kv. cable in service there is no question about the possibility of manufacturing and operating such cable when needed. The knowledge and experience gained on oil filled cable in service, on field tests and in the laboratory have demonstrated that without doubt, 220-kv. cable can be made to operate with as high a factor of safety as 132-kv. cable, without exceeding dimensions that are entirely practical. In so far as joints are concerned, the development of the condenser type joint with complete control of the distribution of stress makes it possible to design a joint with reasonable dimensions which will be as safe at 220 kv. as the present condenser joints are at 132 kv. The terminals will present no problem, and of course the external equipment such as reservoirs will be essentially the same as that in use at present.

A breakdown test made on a sample of 220-kv. cable is shown in Fig. 12. This cable was tested starting with 250-kv., 60 cycles between conductor and lead, the voltage being raised 25 kv. at one-minute intervals, up to 500 kv., and was held there for 10 minutes. The voltage then was increased by the same steps up to 675 kv., when an arc occurred to the building. A later test was carried to 725 kv., without failure of the cable or terminals. The series of condenser type terminals is of interest, each of three sections having been especially assembled to meet the extreme test conditions imposed by these high values of voltage. It is believed that this is the highest voltage ever applied to a cable.

Carrying Capacity as Affected by Dielectric Loss

The curves in Fig. 13 are of interest and are self-explanatory. It will be seen that power factors which are obtained at the present time do not cause any serious loss in carrying capacity of cables in existing ranges of voltage. An examination of the curve for 330 kv., however, indicates that there will be some very difficult problems to solve in order to avoid undue reduction of carrying capacity due to dielectric loss when cables at this extreme voltage are required.

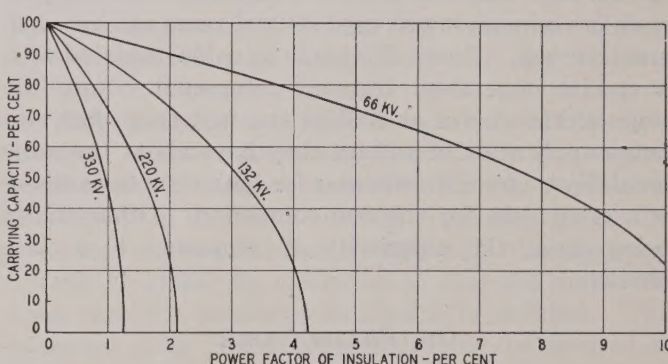

Fig. 13. Carrying capacity of oil filled cable as affected by dielectric loss. Capacity expressed in percentage of maximum possible

Curves are calculated on the basis of a 2,000,000-cir. mil single-conductor cable with one circuit per duct bank

Future Trends

The road of a prophet is one of great difficulty and should be approached with caution. There are, however, some quite definite tendencies and trends apparent in the cable industry which has already entered a rather revolutionary stage. An illustration of the remarkable improvements that have been made by the cable manu-

facturers hand in hand with the utilities is the fact that in a short period of about six years from about 1921 to 1927, the maximum operating voltages of underground cables increased successively from 27 kv. to 33 kv., to 45 kv., to 66 kv., and up to 132 kv.

What made the last step possible and what makes still further progress possible is the advent of the oil filled cable idea. It should be emphasized that the oil filled cable has shown not only an ideal solution of all high voltage cable problems but it has demonstrated clearly the fundamental cause of early difficulties. It was well known that cable troubles from defective insulation, when they occurred, usually were due to deterioration caused by ionization and voids in the insulation. The writer does not believe, however, that there was any general appreciation of the fact that these voids were caused by the expansion and contraction phenomena of the cable compound with load cycles. The oil filled cable system is a complete cure to all these difficulties; however, now that the cause of the trouble has been thoroughly understood, cable engineers all over the world are searching for other solutions. If something could be placed in a cable which would expand and contract as the compound contracts and expands, void formation might be minimized. There is a multitude of new ideas on this subject, based on the fundamental idea that it is as illogical to make cables as they have been in the past as it would be to make a large bridge without an expansion joint.

Out of these many ideas involving large scale research, some practical results will doubtless evolve. In the opinion of the writer, the real oil filled cable will continue to be the ideal form. This is said primarily because not only does the oil filled cable completely take care of expansion and contraction phenomena of oils, but an oil filled cable has a degree of initial perfection that probably cannot be attained with any other form. Whether some of the special forms mentioned above will be economically justified in the middle-voltage range has yet to be proved.

Along with important developments in rubber and varnished cambric, undoubtedly the greatest future development will be in the increased economy with oil filled cables at present voltages, due to the reductions in insulation thickness and in cost of accessories which would make possible its use at lower voltages. At the same time we shall see oil filled cables at higher and higher voltages.

Time Factor in Telephone Transmission

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Although the time factor in telephone transmission has been discussed in several technical papers, there seems to have been none giving a general over-all picture of the subject. Such a picture is presented briefly in this article.

RAPID EXTENSION of the distances over which commercial telephony is given and the introduction of long telephone cables have introduced time problems in telephone transmission which are of great difficulty and technical interest.

The more important of these problems are the following: (1) The slowing down of conversation by the time interval between the formation of a sound by the speaker and its reception by the listener; (2) distortion of speech by the differences in the speed of transmission of the different frequencies which form it; (3) echo effects which arise from the reflection of energy at points of irregularity, particularly at the ends of a circuit; (4) interference with voice operated devices which may be connected in a circuit to overcome echoes or to stabilize the circuit; and (5) fading in radio circuits which may result from the different times of transmission of the signals over separate paths between the transmitter and receiver. This last matter, however, is outside the discussion of the present paper which is confined to the conditions where not more than one path is involved in the transmission in either direction.

The speed of transmission in which we are interested in this paper is that at which signals pass along the line. This may be quite different from the speed at which the crests or troughs of the waves travel along the line when a single frequency potential is applied continuously at the sending end. In fact in some forms of artificial circuit the crests and troughs may travel toward the sending end.

Based upon "The Time Factor in Telephone Transmission" (No. 31-135) presented at the A.I.E.E. South West District meeting, Kansas City, Mo., Oct. 22-24, 1931.

Table I—Speed of Transmission

Type of circuit	Approx. speed miles/second
Cable circuits loaded with 88-mh. coils at 3,000-ft. spacing	10,000
Cable circuits loaded with 44-mh. coils at 6,000-ft. spacing	20,000
Cable pairs of non-loaded 16 B&S gage	130,000
Non-loaded open wire pairs	180,000
Radio	186,000

Since the speed of signal transmission is generally different for different frequencies, we must consider at a time only a single narrow frequency range. We may suppose for convenience that electrical filters are applied to the circuit so that only frequencies within this narrow range can be effectively applied to it. If a voltage having a frequency, say, at the midpoint of this narrow range is applied to the circuit for a short interval and then removed, the speed at which the disturbance thus set up travels down the circuit is the speed in which this article is concerned. A spurt of energy of this type is evidently similar to that which takes place in a carrier telegraph system when a dot impulse is applied to the circuit.

On this basis the approximate speeds of a number of standard constructions which represent good engineering practise today are given in Table I. These figures are for bare circuits. In actual circuits the speeds are reduced 10 to 25 per cent by the apparatus necessarily inserted at the terminals and at intermediate points along the circuit.

Considering the first of the time problems listed above—that is, the slowing down of telephone conversation—it may be noted this does not interfere with one-way transmission. It does, however, slow down two-way conversation by the time required for the transmission of a question to the distant end and the time required for the return of the answer. Non-loaded open-wire, non-loaded cable, and radio are all sufficiently fast so that this effect does not interfere with their use for telephoning between any two places in the world. In fact this problem is not a pressing one for the largest distances within the United States even with loaded construction of the types now standard for long circuits. We must consider in the future, however, the joining together of long lengths of cable in this country and long lengths in Europe with possibly long lengths of intervening submarine cable. If two persons talked over a circuit of such great distances with the present types of loaded toll cables, each would feel that the other was somewhat sluggish in his replies.

Tests have been carried out to determine what magnitude of delays is permissible. Several methods of conveniently introducing delays have been employed in these tests. The method found the most useful is that illustrated by Fig. 1.

Two long brass pipes looped back and forth to conserve space are equipped with loudspeakers at their ends. One of these pipes is connected by means of its loudspeakers into the circuit for transmission in one direction, while the other is connected for transmission in the opposite direction. At the sending end of each pipe the loudspeaker converts the electrical energy into sound energy, and at the receiving end of the pipe the loudspeaker reconverts the sound energy back into electrical energy. Amplifiers and other control devices are used to give the desired transmission efficiency and to conserve the wave form. As great a time interval is required for 75 ft. of such transmission through air as for radio transmission half way around the world.

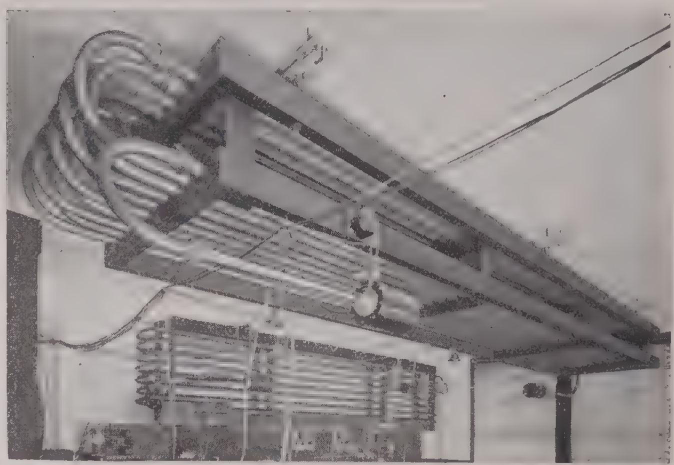

Fig. 1. Experimental acoustic delay circuit

Using devices of this nature, experimenters have found it possible to talk fairly conveniently over circuits representing time intervals as great as 0.7 sec. in each direction. Such great delays, however, would be considered undesirable for commercial use. Generally, delays of about one-third of this are considered the maximum which is satisfactory.

The second problem noted above is the distortion produced when the different frequencies making up speech are transmitted with different velocities. These effects may occur in one-way circuits as well as in two-way circuits and are not related to echo effects. The appearance of these transients to the listener depends on whether the excess delay is at low or high frequencies. It is rather difficult to describe the characteristic sound of a circuit with low-frequency delay. High-frequency delay, if extreme, sounds as though a high pitched reed, such as a harmonica reed, was being plucked whenever a sudden transition occurs in the voice sounds.

The appearance of such transients is shown conveniently by the aid of oscillographs of spurts of alternating current taken before and after being sent over circuits having various delay characteristics. If a frequency f is suddenly applied to the sending end of a line, and if all frequencies are transmitted over the line with the same attenuation and at the same speed, the wave at the receiving end will duplicate exactly in form the wave at the sending end. Any departure of the line from these ideal characteristics causes transient effects

at the receiving end as the incoming wave establishes itself, although ultimately the pure wave of frequency f is established.

An oscillogram is reproduced in Fig. 2 showing a spurt of 1,600-cycle current as applied to, and received from, a loaded cable circuit having fairly large delays in the upper part of the transmitted frequency range compared to the delay at lower frequencies. It will be observed that the current at the receiving end consists at first of a fairly low frequency which builds up in both frequency and magnitude to the steady state value. At the end of the spurt the same transient is experienced, but in this case the higher frequency currents which have been delayed more in the line are at the tail end of the train.

Transient effects of a particular type of a composited, loaded 19-gage cable circuit are shown in Fig. 3. The small variations in the zero line of the curves, due to cross-talk and other interferences, should be neglected. The upper line of the figure shows an applied 1,000-cycle current; the second line shows its form as it was received, disclosing transients; and the third line shows it at the reception point after it had been passed through a correcting network applied in series with the circuit. While the delay in the reception of the signal had been somewhat increased as indicated by the displacement of the signal further to the right, the transients at the beginning and ending of the signal are reduced very greatly.

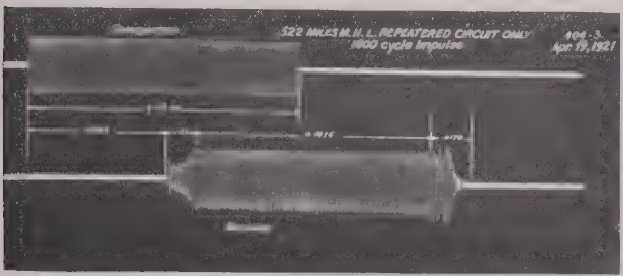

Fig. 2. Transients in medium heavily loaded circuit, showing delays in upper part of the range

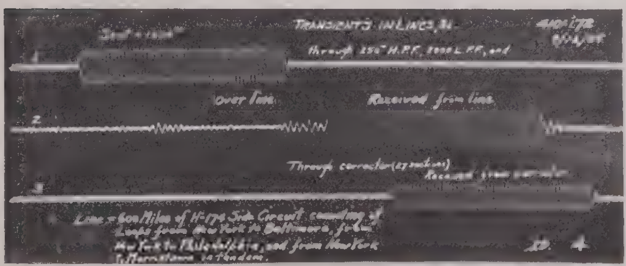

Fig. 3. Transients in medium heavily loaded cable circuit, showing effect of corrector

Excess delay at low frequencies may be present in a circuit due to the apparatus which is inserted in it.

The third problem listed includes the effects of echoes. Reflections of voice waves in all practical telephone circuits arise from impedance irregularities. It is only in telephone circuits of such length as to require a number of repeaters that echo effects become serious. The fact that the circuits are electrically long makes the time lag of the echoes appreciable. At the same time the telephone repeaters overcome the high attenuation and make the echoes louder.

Some of the reflected waves return to the receiver of the talker's telephone and if loud, may give him an uneasy feeling that the distant party wishes to interrupt. Other reflected waves enter the listener's telephone and if severe, cause him to hear an echo following the directly received transmission.

The simplified diagram of Fig. 4 shows a four-wire circuit in which the effective echoes are limited necessarily to those caused by the two ends, since separate paths are used for east and west transmission. The lower part of the figure suggests the paths which the echo current may follow. The balancing arrangements used at the ends of such a circuit assist of course in keeping down the amount of echoes present.

A form of device used to overcome echoes is indicated in simplified form in Fig. 5. This figure will serve also to illustrate the fourth problem listed above; that is, interference with voice-actuated devices of this kind. The circuit shown is similar to that of Fig. 4 but with an echo suppressor so arranged that energy transmitted in one direction short-circuits and thus disables the path of the circuit going in the opposite direction. In this way echoes from the distant end cannot be transmitted back to the receiving end

If the delays in such a circuit are large and the adjustments not well made, it is possible for one subscriber talking fairly steadily to hold the suppressor operated so continuously that it is difficult for the other party to interrupt even if he so desires. Under similar conditions, if one subscriber starts to reply almost simultaneously with the termination of the other's speech, there may be some clipping at the beginning of his reply by the echo suppressor. More involved difficulties arise when there are two or more such devices at different points in a circuit.

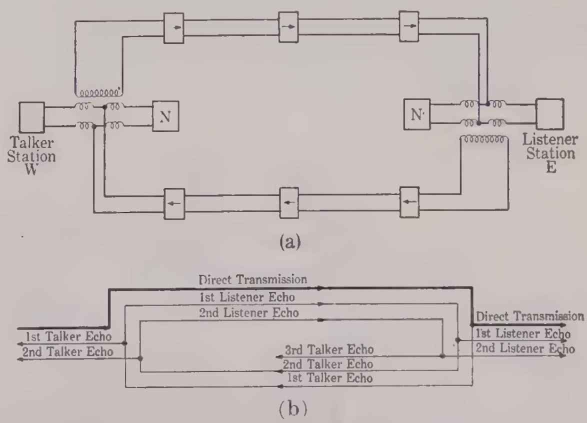

Fig. 4. Diagram of a four-wire circuit

Long radiotelephone circuits may vary so greatly in transmission effectiveness that if they were arranged to be operative in both directions at a time, it would be difficult to prevent their becoming unstable and setting up oscillations. Voice-actuated devices somewhat similar to echo suppressors but more elaborate are therefore employed on such circuits to stabilize them. With this arrangement the circuits leading to both radio transmitters are normally disabled. The speech waves starting from either end, therefore, must operate devices to put the transmitter at that end into working condition and to disable the receiving circuit at that end. Evidently arrangements of this kind need even greater

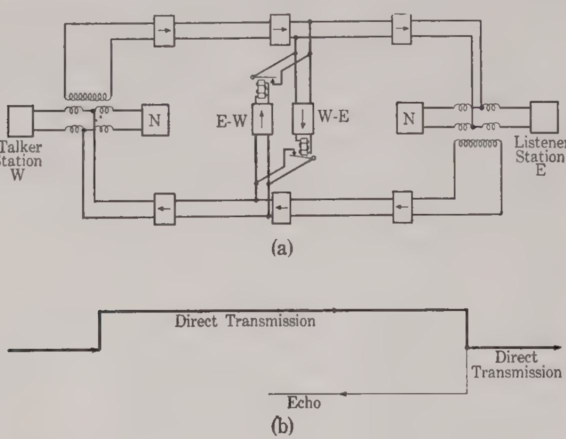

Fig. 5. Four-wire circuit with echo suppressor

care in design and adjustment to prevent clipping of speech and to avoid making interruption by the listener difficult.

An interesting application of time delay has been made in connection with radio systems so operated. In this the voice currents on reaching the disabling point are passed through an artificial line in which a desired amount of delay is incorporated. Just before entering this line a part of the energy is taken, rectified, and made to operate the switching mechanisms for restoring the circuit to operating conditions. This switching is completed by the time the voice currents have passed through the artificial delay circuit and are ready to proceed down the line. If it were not for this arrangement a small part of the speech currents might be lost during the interval while the switching mechanisms were operating.

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Electrical Precipitation

Although Cottrell smoke precipitators have found application in a variety of industries, theoretical features of the process and fundamental laws underlying it have not been subjected to very close scrutiny. Experiments described here were made to determine the effect upon "precipitation efficiency" of many of the variables entering into the process.

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COTTRELL TREATERS have found many applications in various industries for the recovery or removal of smoke, dust, and fume particles from their containing gases; yet the fundamentals of the process have received but scant attention. In order to put this process on a more quantitative basis an experimental and theoretical study was made in this laboratory, in which were investigated the effects upon the *precipitation efficiency* or percentage removal, of various fundamental variables such as the operating voltage, secondary current, gas velocity, concentration of the dispersoid, size of discharge electrode, and other factors.

The underlying theory of the process has been covered in previous publications, but for the purposes of this article, the following is quoted from "Electrical Precipitation of Solids from Smelter Gases," by Ross B. Rathbun, A.I.E.E. Trans., V. 41, 1922, p. 816:

"This (the precipitation) is accomplished through the ionization of the gas which carries the particles in suspension. It is assumed that the negative ion or electron is the ionizing agent and that the velocity of the electron stream is sufficient to ionize the gas molecules by collision in a relatively small zone near the discharge electrode where the potential gradient is steepest. This stream of electrons in making its way toward the opposite electrode is assumed to charge the minute dust particles in passing by contacting or attaching to the particles. The latter having acquired a negative charge, and being in a strong electrostatic field, are attracted by the positive pole and hurled against it with considerable force, where they give up their negative charge to this electrode and cling to it (the electrode) by adhesion."

Thus the process may be seen to consist simply of passing the fume-laden gas through a unidirectional electrostatic field in which a corona discharge is maintained. The dust particles first are charged by the electric field and then swept out of the space between electrodes.

The theoretical development of the present article was based upon the assumption that the chance of a particle being precipitated depends merely upon its chance of encountering an ion, and this led to the equation

$$\eta = 1 - e^{-\alpha t} \tag{1}$$

where η is the percentage removal (expressed as a fraction) t the treatment time, α a constant for a particular precipitator treating a given fume or dust, and e the base of the hyperbolic system of logarithms. This equation enables an immediate deduction of the effect of the distance L traversed by the gas in the precipitator and the gas velocity V, since the time t is merely the quotient of these two. This leads to the equation

$$\eta = 1 - e^{-\frac{\alpha L}{V}} \tag{2}$$

From eq. 1 also the effect of increasing the effective cross-section of a treater or its length, or the equivalent process of connecting similar treater units in parallel or in series, can be deduced immediately. Since time t is the only variable factor appearing in the right-hand member of eq. 1, for a given constant gas volume treated per minute in a given number of precipitators, how these are connected has no import as regards the resulting efficiency, for the length of path is increased in a series connection in the same ratio as the velocity

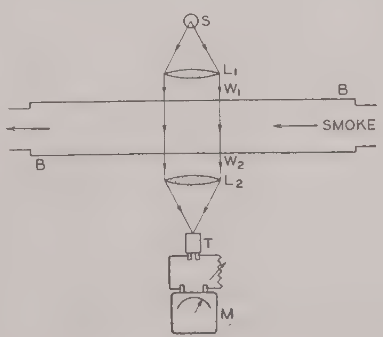


Fig. 1. Special photometer for determining smoke concentration

From "Some Fundamental Theory and Experiments on Electrical Precipitation" (**No. 32-32**) presented at the A.I.E.E. winter convention, New York, Jan. 25-29, 1932.

is decreased in a parallel connection. In other words, a given number of units can be connected all in series or all in parallel without any difference in the theoretical efficiency. The same holds for symmetrical series-parallel connections.

Special Apparatus Developed

One of the chief difficulties in experimenting with the action of the Cottrell treater has been the lack of a quantitative method of determining the instantaneous dust or smoke content of the gas entering or leaving the precipitator. In these experiments this difficulty was solved by means of an optical (photometer) method; specifically, by measuring the light absorbed by a definite column of the smoke-laden gas. For a dust of constant composition and physical characteristics it can be shown that the concentration is proportional to the logarithm of the ratio of the incident to the transmitted light. The factor of proportionality depends upon the nature of the dust or smoke to be measured.

Apparatus used for measuring the dust concentration is shown schematically in Fig. 1. Light coming from small lamp s is rendered parallel by the lens L_1, then passes through the window W_1 into a long rectangular box B carrying the smoke-laden gas; from a second window W_2 on the other side of the box the light emerges, reduced in intensity by a fraction depending upon the concentration of the smoke; then by means of a second lens L_2 the light is concentrated on a light-sensitive element which sends a current through the meter M proportional to the intensity of light acting upon it. Two such metering devices were used, one on the inlet and the other on the outlet side of the experimental precipitator.

The experimental precipitator used is shown diagrammatically in Fig. 2. It consists essentially of a cylinder (pipe) with an insulated wire electrode stretched inside along its axis. The wire is held in place by heat-resisting glass insulators at either end, the necessary corona-forming potential being supplied by a lead brought into the cylinder through a bushing also of heat-resisting glass. The high voltage supply consisted of a pulsating direct current obtained from a half-wave vacuum-tube rectifier.

For the material to be precipitated oil smoke was used, this being generated by a specially designed

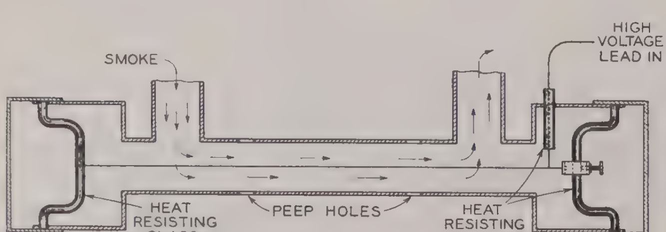


Fig. 2. Cottrell electrical precipitator used in the experiments of this article

"smokifier" which allowed the formation of a constant stream of smoke of constant characteristics. This device consisted merely of a copper U-tube immersed in a molten lead bath; smoke was formed by simply feeding a thin stream of oil into the hot tube; the resultant smoke was blown out by a stream of air. Strictly speaking, this device generates an oil "mist" rather than a true smoke, the oil itself not being carbonized but merely vaporized and recondensed in the precipitator.

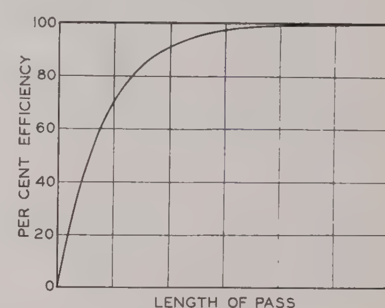
Experiments were carried out by passing the oil smoke first through one of the specially designed optical photometers where its initial concentration was observed; next the smoke was passed into the precipitator to which variations in the different factors involved in the investigation were applied. From the precipitator the gas was piped through a second optical photometer where its final concentration was observed.

Results

In general the experiments showed that the precipitation efficiency increases with the treatment time, voltage, current, and power, according to a curve which partakes of the nature of that for a condenser charge; or, in other words, they are exponential relationships.

Fig. 3. Theoretical precipitation efficiency of a Cottrell treater as a function of its length

Curves for electrode voltage and current would have similar shapes



Curves representing these relationships thus rise steeply at first but at a continually decreasing rate; then bend over and eventually approach the value of 100 per cent efficiency asymptotically. This is depicted graphically in Fig. 3, which is a theoretical curve of the precipitation efficiency plotted as a function of the treater length. For a given gas volume treated per minute or constant gas velocity, the treater length is proportional to the treatment time. From this curve it may be seen that in general the cleaner a gas becomes the harder it is to make it still cleaner. After the first 90 per cent of the smoke particles has been removed, just as much additional apparatus is required to remove an additional 9 per cent of the original content than was necessary to remove the first 90 per cent, and so on. From the theoretical point of view this is due to the fact that the cleaner the gas becomes (that is, the smaller the concentration of the dispersoid) the smaller becomes the chance of a single particle of the dispersoid encountering an ion.

In addition to the general results just outlined, cer-

tain other peculiarities of importance were noted. Surprising as it may seem, the value of the operating voltage, in so far as it determines the electric field, apparently has but little effect upon the cleaning efficiency. The function of the field is only to sweep the particles, once they have become charged, to the collecting electrode; for this purpose over a wide range the exact value of the field and consequently of the applied voltage is of secondary importance. The same holds for the size of the discharge electrode; the latter merely determines the operating or corona-forming voltage.

Of fundamental importance, however, is the current flowing between electrodes and through the smoke-laden gases within the precipitator; and for different discharge electrodes and operating voltages it was found necessary only to duplicate the current to duplicate the precipitation efficiency. The current itself is affected by the concentration of the dispersoid entering the precipitator, being considerably depressed if the concentration is high, and *vice versa.* The resulting corona characteristic (current-voltage curve) of the precipitator under load thus depends upon the concentration of material entering the precipitator.

While the present theoretical and experimental study, upon which this article is based, is thought to be more extensive perhaps than most others that have been made before, it is considered to be still far from complete. It is hoped that the experiments described and the experimental methods developed will stimulate further research in this highly interesting field.

Stability Experiences with Conowingo Hydro Plant

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During the first year of operation, four cases of instability developed at Conowingo hydroelectric station of the Philadelphia Electric Company when faults occurred on the transmission lines. Subsequent investigations showed that some of the generators would advance 180 deg. ahead of the system in less than 0.3 sec. when full load was dropped suddenly. Installation of higher speed relays and circuit breakers together with changes in the operating set-up, have corrected the situation.

STABILITY of electric power systems is becoming of more general interest and concern since the advent of large hydroelectric stations located at considerable distances from their loads, and with the general interconnection of large capacity power systems. Many papers and articles dealing with methods of calculating stability have appeared, but comparatively little information has been published showing the experience on actual systems. Such experience is of value as an indication of what may occur on other systems of similar character and also in determining the basis for design of new projects.

A typical example of a generating station susceptible to instability under certain conditions of severe line faults is the 252,000-kw. Conowingo hydroelectric station which is situated 58 miles from the main system of the Philadelphia Electric Company and ties in with that system and the 220-kv. Pennsylvania-New Jersey interconnection by means of two 220-kv. lines. During the four years the plant has been in service, studies of the stability of this system have been made, and considerable operating experience has been obtained including several cases of instability. As a result several changes have been made to improve system performance. Automatic oscillographs to record system performance during faults are installed permanently, and a great many records have been obtained. No operating tests to determine stability have been made, though several short circuit tests were conducted on the 220-kv. system to determine high speed relay and oil circuit breaker characteristics, these being intimately associated with stability.

Based upon "Stability of Conowingo Hydroelectric Station of Philadelphia Electric Company System" (No. 32-25) presented at the A.I.E.E. winter convention, New York, Jan. 25-29, 1932.

Extent of System Involved

The system involved (see Fig. 1) consists of the Conowingo hydroelectric station with seven 36,000-kw.

generators connected by two 58-mile 220-kv. lines to Plymouth Meeting substation, a junction for two lines of the Pennsylvania-New Jersey 220-kv. interconnection, and for connection with the main part of the Philadelphia Electric system through step-down transformers. Three 10-mile 66-kv. aerial lines connect from Plymouth Meeting to Westmoreland substation, from which point lines radiate to the main part of the Philadelphia Electric system where most of the Conowingo output is used.

Pennsylvania-New Jersey interconnection as indicated consists of 220-kv. ties between the Philadelphia Electric Company system at Plymouth Meeting, the Pennsylvania Power and Light Company system at Siegfried, and the Public Service Electric and Gas Company system at Roseland. The interconnected systems are all of large capacity, having respective peak loads in 1930 of: Philadelphia Electric Company, 699,000 kw.; Public Service Electric and Gas Company, 540,500 kw.; and the Pennsylvania Power and Light Company, about 350,000 kw.

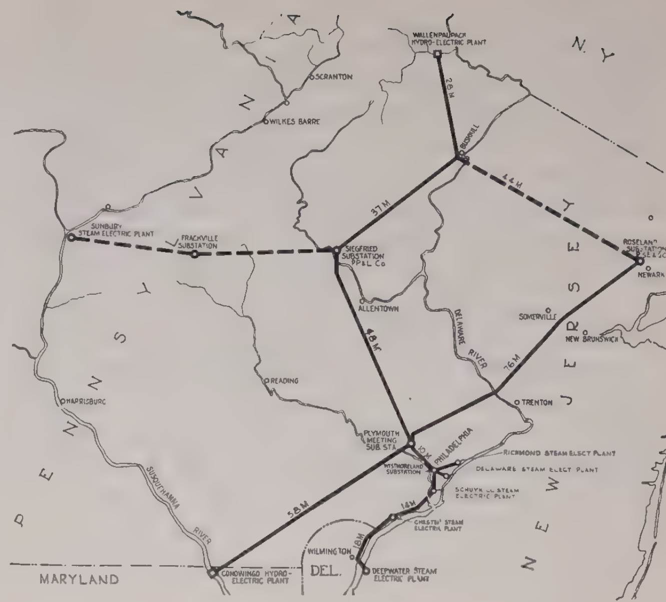

Fig. 1. Map of Philadelphia Electric Company high voltage system showing also lines of the 220-kv. Pennsylvania-New Jersey interconnection

Preliminary Stability Study

Extensive stability calculations and studies were made before the 220-kv. system was built to check stability in case of line faults. The faults were assumed to involve only one phase since information then available indicated this to be the general experience on 220-kv. systems. These studies were based on the ultimate system development which involves extension as shown by the dashed lines in Fig. 1. Since the system is rather complicated, one of the studies was made with a mechanical model.[2] (For numbered references see bibliography.)

Results of the stability studies showed that in general synchronism could be maintained for practically all expected fault conditions, although considerable swinging was indicated for some conditions. On account of this swinging condition together with uncertainty regarding some of the factors assumed in the study, such as clearing time and fault resistance, it was considered advisable to incorporate in the design several special features for increasing stability.

Measures provided with the initial design, for increasing stability and reliability, may be divided into two general classes: (1) preventive and (2) remedial. The first class aimed to prevent faults by means of heavy insulation and protection against lightning with double ground wires for each line, shielding for substation structures, and installation of lightning arresters at the substation.[3,4] The second or remedial class included steps to clear faults quickly should they occur, and measures to stiffen the system in case of transient disturbances. In this connection a special relay system designed to clear all faults with minimum delay was installed. Oil circuit breakers used were designed to interrupt fault current in less than 0.5 second; at the time of their installation these were the fastest available

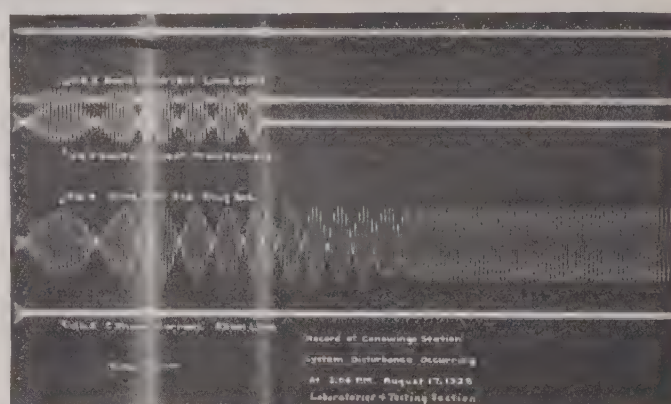

Fig. 2. Oscillogram of system disturbance August 17, 1928. Instability caused by two-phase fault on Conowingo line

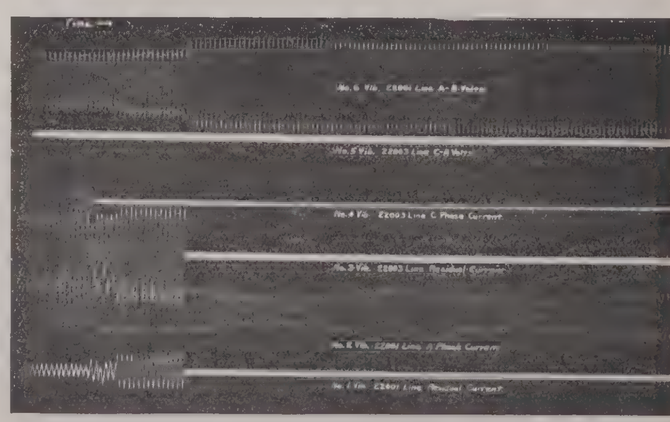

Fig. 3. Oscillogram of system disturbance January 14, 1930. Stability maintained through single-phase fault on Conowingo line (full station load)

Table I—Faults on Plymouth Meeting-Conowingo 220-Kv. Lines

Year	1928			1929				1930				1931			
Date	6–9	7–4	8–17	6–14	6–15	7–29	8–21	1–14	6–26	7–6	7–21	5–10	7–9	7–9	7–24
Time	5:27 p.m.	4:12 p.m.	3:06 p.m.	11:48 p.m.	1:21 a.m.	4:12 p.m.	5:06 a.m.	12:31 p.m.	7:48 p.m.	7:19 p.m.	7:14 p.m.	8:52 p.m.	7:41 p.m.	9:01 p.m.	1:47 a.m.
Cause	Ltng.	Ltng.	Ltng.	Ltng.	Ltng.	Ltng.	—	Ltng.	Ltng.	Ltng.	Switch failure	Ltng.	Ltng.	Ltng.	Ltng.
No. phases faulted	2	2	2	1	1	2	1	1	1	1	1	2	1	3	1
Miles from Ply. Mtg.	2	53	4	—	—	—	—	17	28	—	0	18	5	22	33
*Residual amperes, Con.	—	—	—	Open	Open	—	Open	915	500	420	450	1,370	940	—	Open
*Residual amperes current, Ply.	—	—	—	1,300	1,350	—	—	—	700	3,000	—	2,600	4,500	—	2,600
†Pos. sequence kv., Ply.	—	—	—	—	—	—	—	—	115	87	98	76	95	—	115
Clearing time, Con. (cycles)	—	10	102	Open	Open	69	Open	45	107	71	37	11	12	‡40–50	Open
Clearing time, Ply. (cycles)	—	62	20	18	16	20	35	31	35	33	55	8	15	"	8
Load, Conowingo	168	112	140	30	0	66	0	263	170	92	150	235	145	165	35
Load, P. E. steam gen.	34	46	220	225	211	349	226	159	258	145	323	89	248	241	163
Load, P. E. system	202	158	360	252	207	423	250	392	390	223	473	319	345	396	207
220-kv. system set-up	Solid	Solid	Solid	Solid	Solid	Solid	Solid	Solid	Split	Solid	Solid	Solid	Solid	Solid	Solid
Conowingo stability	Unstable	Unstable	Unstable	OK	Off	OK	Off	OK	OK	OK	OK	OK	OK	Unstable	OK
Conowingo power swings after fault cleared	—	—	—	—	—	—	—	‡200–325	75–100	70–110	130–155	164–292	114–185	+313–313	31–38

*Measured in faulted line. †Equivalent line to neutral voltage; normal value 127 kv. ‡Estimated. All load and power values given in megawatts.

for such high voltage service. The generators were built with as low transient reactance as possible consistent with reasonable cost and efficiency. To obtain low reactance in these machines was rather difficult because of their slow speed (80.8 r.p.m.) but it was possible to reduce the transient reactance to about 29 per cent and still have a fairly well-balanced design. Transformer reactance was kept as low as was possible with safety, and this resulted in a value of about 9 per cent. The Plymouth Meeting transformers were so arranged that the synchronous condensers connected to their tertiary windings would be closely coupled to the 220-kv. system in order to secure maximum benefit from them in maintaining stability.

One 30,000-kva. condenser is provided for each of the three transformers at Plymouth Meeting, and these condensers have rather special excitation as described in a previous publication.[5] In case of a system disturbance the exciter voltage is increased automatically at a rate of over 6,000 volts per second, and the load on each condenser increases from a normal value of 10,000 kva. to about 58,000 kva. in 0.5 sec. Two additional condensers with automatic high speed excitation are installed at Westmoreland substation and the 60-cycle motors of many frequency converters on other parts of the Philadelphia Electric system are used as condensers, all of these being provided with automatic voltage regulators. Conowingo generators have special high speed excitation, designed to prevent a drop of more than 2 per cent in their induced voltage when full-load lagging reactive kva. is applied suddenly while carrying full rated load at unity power factor.

Instability Experienced with Initial Operation

During the first year (1928) three faults, all caused by lightning flashovers, occurred on the Plymouth Meeting-Conowingo lines; each fault involved two phases instead of only one as expected and assumed as the basis for design. Conowingo became unstable for each of these faults and also on one other occasion when a severe disturbance occurred due to an oil fire and explosion along the Chester-Schuylkill lines of the 66-kv. system. (See Table I.)

This experience during the first year, when every fault on the Plymouth Meeting-Conowingo line caused instability, naturally was very alarming and extensive study was given to determine the cause of the trouble, and to ascertain what could be done to correct the condition. The study was handicapped at first by a lack of definite records of the time and sequence of events. Some doubt existed regarding the performance of relays, switching time, and operation of the governors. In addition, all four cases of instability occurred before the installation of synchronous condensers was complete and before the high speed excitation system was working satisfactorily.

While practically no interruption of service to customers resulted from these disturbances, it was realized

that something must be done immediately to increase the reliability of Conowingo station, therefore a number of temporary measures were adopted pending the outcome of further study and experience.

It was evident that most trouble was likely to occur during lightning storms; also that service to the customer could be maintained by providing sufficient steam reserve. Arrangements were made therefore with station attendants and line patrolmen to watch for electric storms, and to report their appearance to the system load dispatcher; the load on Conowingo then could be reduced and the steam reserve built up. A practise also was adopted of operating the 220-kv. system split so that Conowingo would operate in two separate sections during storms if four or more generators were running. While this meant the certain loss of half the station with a fault on either line, it greatly reduced the chance of losing the entire station. Use of this storm set-up was discontinued in 1931 when changes had been made in some of the equipment so that it no longer was required.

Special Tests

While relief was obtained by the temporary measures just outlined, a series of tests was made to check practically all uncertain factors affecting the performance of the system. The most comprehensive of the tests was a series of single-phase and two-phase faults made at various locations on the Plymouth Meeting-Conowingo lines, records being obtained on all parts of the system by observers and special recording equipment. These tests were made with most of the synchronous equipment and lines in service, but without load because of the danger of disturbing customers. A total of 29 oscillograph elements were used in the test, connections to these being shifted to measure various quantities for the different faults. High speed moving pictures were taken of all faults and of the governors on several generators.

Principal conclusions from this series of tests were as follows:

1. Relay operations were correct and all faults were cleared with more than sufficient margin to prevent the disconnection of any equipment other than the line faulted.

2. Over-all clearing time for faults including switching and relay operation was somewhat longer than expected, averaging a little over 0.5 sec. for the first switch and 1.0 sec. for the second switch.

3. No serious swinging of one Conowingo generator against another was observed.

4. No hunting of governors occurred.

5. Faults were apparently of low impedance and did not "blow" from one conductor to another.

6. The high speed excitation system was not performing as well as expected.

7. Calculated short-circuit currents were in reasonably close agreement with actual test values.

Another test which was made consisted of opening switches on the Conowingo generators while the machines were carrying load. This was done to ascertain the speed characteristics and governor response of these units as well as furnish a service check of the overspeed and overvoltage protection. This test showed that the speed increased so rapidly when full load was dropped that some of the units advanced 180 deg. ahead of the system in less than 0.3 sec. This naturally explains how the plant can get out of synchronism so quickly when the electrical output is reduced seriously by the voltage reduction caused by a severe system fault.

Special tests were made also on the synchronous condensers under load conditions to check the operation of the high speed excitation system and to determine the best adjustments; after some changes had been made, performance was brought up to expectations. The test on the Plymouth Meeting condenser is described in a previous publication.[5] Still another test was the measurement of zero sequence reactance of the Conowingo lines. This consituted one of the uncertain factors assumed in the calculations; the test showed that the measured value was in close agreement with that used in the calculations.

Supplementing the information obtained in the special tests, complete records and reports of each system disturbance are obtained by the following means:

1. Automatic Oscillographs

As soon as obtainable, automatic oscillographs were installed permanently at Conowingo and at Plymouth Meeting, a six-element instrument at the former station and a seven-element unit at the latter; most of the time a second six-element oscillograph has been in use at Plymouth Meeting. A four-element Hall recorder is installed at Westmoreland. To obtain records of field experience and special information additional oscillographs

Table II—Faults on Plymouth Meeting-Siegfried and Plymouth Meeting-Roseland 220-Kv. Lines

Year	1928		1929	1930			1931	
Date	7–12	7–24	8–13	6–26	7–9	12–10	7–14	9–6
Time	5:15 p.m.	8:02 a.m.	11:37 a.m.	7:12 p.m.	10:17 p.m.	4:17 p.m.	6:14 p.m.	4:28 a.m.
Line	Sieg.	Sieg.	Sieg.	Sieg.	Sieg.	Rose.	Rose.	Sieg.
Cause	Ltng.	Ltng.	Ltng.	Ltng.	Ltng.	Foreign object	Ltng.	Switch failure
No. phases faulted	1	1	1	1	1	1	1	1
Miles from Ply. Mtg	40	15	35	17	14	65	—	0
*Residual amperes, Ply	1,000	1,440	1,070	1,840	1,750	600 +	2,000	—
†Pos. sequence kv., Plymouth	—	—	—	92	98	—	115	—
Clearing time, Ply. (cycles)	65	65	92	30	35	71	8	150
Load, Conowingo	208	218	41	120	25	0	172	28
Load, P. E. steam gen	65	173	341	221	262	434	150	134
Load, P. E. system	263	395	349	369	323	453	312	179
220-kv. system set-up	Solid	Solid	Solid	Split	Solid	Solid	Solid	Solid
Conowingo stability	OK	OK	OK	OK	OK	Off	OK	Tripped
Conowingo power swings after fault cleared	—	—	None	95–142	20–25	Off	166–181	—

*Measured in faulted line. †Equivalent line to neutral voltage; normal value 127 kv. All load and power values given in megawatts.

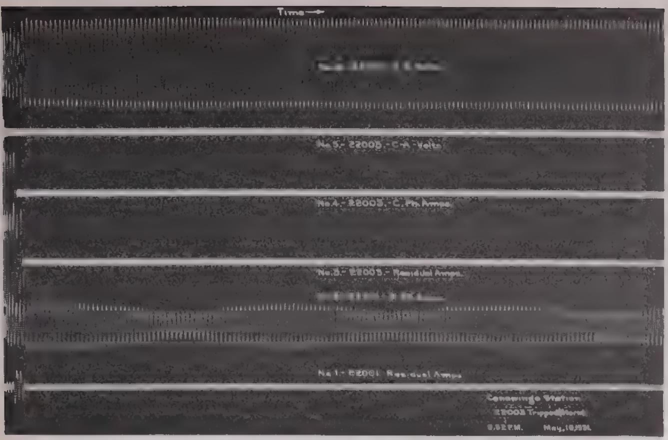

Fig. 4. Oscillogram of system disturbance May 10, 1931, showing operation of high-speed circuit breakers. Stability maintained through a two-phase fault on Conowingo line

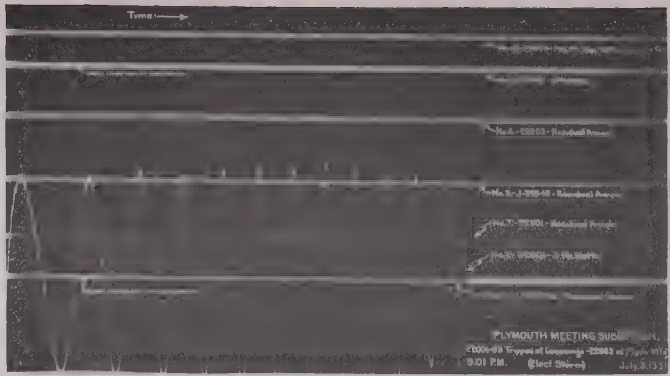

Fig. 5. Oscillogram of system disturbance July 9, 1931. Instability resulting from three-phase fault on Conowingo line

and recorders have been installed temporarily from time to time. These oscillographs record residual current in all lines, power in each of the Plymouth Meeting-Conowingo lines, positive sequence voltage, and selected line currents and voltages. They are started automatically with station residual current, but arrangements are being made to start them also with line current, since three-phase faults recently experienced have had insufficient residual current for this purpose.

2. Reports from Station Operators

Most of the relays are equipped with operation indicators and the more important relays are connected to a drop signal system so that it is possible to see which relays operate for each disturbance. Thus usually it is possible to determine the phases which are faulted, and the general fault location. Operators are instructed to note the time of each disturbance and to make a record of all relay operations. They report also indications of maximum reading ammeters in the neutral ground connection of the high voltage transformer windings. Graphic recording meters furnish a continuous record of power, voltage, and frequency. Of course station records are kept which show the system set-up and machines in operation at all times.

3. Line Reports

Thorough inspection is made of the line immediately after each fault to determine the damage, location, and number of phases involved.

All available information is collected for each important disturbance and these records are analyzed to determine the cause, number of phases involved, location of fault, fault current, switching sequence, time of clearing, power swings, and other important factors. Records of all severe disturbances have been referred to the major equipment manufacturers to secure their recommendations regarding means of improvement.

In view of the experience with two-phase faults during the first year, further stability calculations were made, based upon this type of fault. These calculations showed that with solid 220-kv. bus operation and heavy load on the plant, a two-phase fault occurring near the end of the line could be expected to cause instability if cleared in approximately 0.5 sec.; however, if the fault was cleared in about 0.15 sec., the system probably would remain in synchronism. A similar study was made for two-phase faults on the Plymouth Meeting-Westmoreland lines; this showed that high speed switching was needed also on these lines.

Equipment manufacturers thought it possible to increase greatly the speed of clearing faults by means of new designs in circuit breakers and relays; and with the need for higher speed operation apparent, they immediately undertook the development of suitable equipment. Some experimental models of new relays and oil circuit breakers accordingly were tested at Plymouth Meeting by means of short circuits on the 220-kv. system. These tests were successful in showing that interrupting time of the order of 0.14 sec. was possible.[6,7]

Equipment Changes to Increase Stability

As a result of the various studies and tests described together with normal development of the system, the following permanent improvements were decided upon:

1. New high speed circuit breakers were provided at Plymouth Meeting and Westmoreland for normal operation on all 220- and 66-kv. aerial lines.
2. The 220-kv. line circuit breakers at Conowingo were rebuilt so that high speed operation was obtained.
3. Relay system was revised and new high speed relays installed on all lines to reduce operating time to about one cycle.
4. A third step-down transformer was installed at Plymouth Meeting.
5. A third 66-kv. line was added between Plymouth Meeting and Westmoreland.
6. The 66-kv. system was split into three separate sections at Plymouth Meeting and Westmoreland.
7. Insulation of the 220-kv. lines was increased from 14 to 16 units for suspension insulators, and from 16 to 18 units for strain insulators.

Operating Experiences Summarized

General experience with Conowingo since 1928 has been quite satisfactory. Many disturbances have occurred due to faults on practically all parts of the system, but since the first year of operation when four cases of instability occurred, various steps have been taken to improve operation. As a result there has been only one additional case wherein Conowingo became unstable. The disturbances have been classified according to the location of the fault on the system and are discussed under six general headings.

Plymouth Meeting-Conowingo line faults. Principal

Table III—Faults in Philadelphia Electric System 220-Kv. Transformers

Year	1928		1929		1930	1931
Date	4–11	12–22	12–28	12–28	5–27	3–28
Time	11:01 p.m.	10:33 p.m.	10:43 a.m.	10:47 a.m.	4:53 a.m.	11:53 a.m.
Station	Con.	Ply.	Con.	Con.	Con.	Con.
Cause	Bushing flashover	Winding failure	Winding failure	Energize faulty trans.†	Winding failure	Winding failure
No. phases faulted	1	1	1	1	1	1
†Pos. sequence kv., Ply	—	—	92	—	90	96
Clearing time, 220-kv. (cycles)	—	26	70	36	40	45
Load, Conowingo	147	90	262	186	186	258
Load, P. E. system gen	119	230	198	256	68	147
Load, P. E. system	222	300	419	419	232	383
220-kv. system set-up	Solid	Solid	Solid	Solid	Solid	Solid
Conowingo load dropped	71	0	64	0	33	36
Conowingo stability	OK	OK	OK	OK	OK	OK
Conowingo power swings after fault cleared	—	—	180–250	60–300	90–270	120–342

†Equivalent line to neutral voltage; normal value 127 kv. All load and power values given in megawatts.

data for each fault experienced on the Plymouth Meeting-Conowingo lines are shown in Table I. Some of the information is only approximate but for the sake of completeness it has been included wherever possible.

Fifteen faults including nine single-phase, five two-phase, and one three-phase have been recorded on the Conowingo lines. Instability resulted from the three-phase fault and from three of the two-phase faults which occurred in 1928 before the high speed circuit breakers were in service.

In 1929 no faults occurred while the station was carrying any great amount of load; so there was no real test of stability during the year. At the beginning of 1930, however, there was a rather unusual experience of an electric storm in winter. This caused a lightning flashover of one phase on one Conowingo line while the station was operating with solid 220-kv. bus and loaded to maximum capacity. Very heavy swinging occurred but stability was maintained. An oscillograph record of this disturbance as obtained at Conowingo may be seen in Fig. 3. Clearing time for this fault at Plymouth Meeting is shown by the length of the first step in the residual current record and the clearing time at Conowingo by the total length of the residual current record. Allowance must be made for the starting time of the oscillograph, which in this case was about eight cycles. The record of voltage on the faulted line is interrupted some time before the fault was cleared, due to the operation of an auxiliary switch on the breaker mechanism. The record of current in one phase of the unfaulted line (No. 2 vibrator) shows the surging after the fault was cleared.

The new equipment for high speed clearing of faults was in service in 1931 and showed its value for the first fault of the year which was a flashover of two phases while Conowingo was almost fully loaded. The fault was cleared from Plymouth Meeting in about eight cycles or 0.133 sec. and from Conowingo in 11 cycles as shown by the oscillograph record from Conowingo (see Fig. 4). Time lost between the beginning of the fault and the first visible record is approximately 3 cycles. Rather heavy surging occurred after the fault, but stability was maintained.

The worst disturbance and the only one which has caused instability since the first year's operation was the three-phase lightning flashover of 1931. The plant was carrying 165,000 kw. and the fault was not cleared for almost a full second because there was practically no ground current, and the only high speed relays in service were ground relays. Since this experience, high speed balanced protection has been added to take care of such conditions. Due to the relatively small ground current, the automatic oscillographs did not start until the circuit breaker had interrupted the fault. No definite record was obtained of the clearing time. The record which was obtained (Fig. 5) is of interest, however, since it shows the power swings of the station out of synchronism with the system. The unfaulted line finally tripped as shown by cessation of power swings. The crest of the power swing was used to check stability calculations by comparison with the crest of the power angle diagram calculated for this condition. These check to within a few per cent, which seems to indicate that the assumptions used in the stability calculations are reasonably satisfactory.

Faults on the 220-kv. Pennsylvania-New Jersey interconnection. Faults experienced on the 220-kv. interconnection lines running from Plymouth Meeting to Siegfried and Roseland are listed in Table II. So far as known all eight faults were single-phase; while most of these were of relatively long duration, none seriously affected stability. It should be noted, however, that the load on these lines is usually rather small, seldom exceeding 50,000 kw. The Roseland line was not placed into service until near the end of 1930, so that on this line comparatively little experience is available. It was equipped initially with high speed circuit breakers, but the first fault was slow in clearing because it was so near the Roseland end of the line that it was outside the zone of operation of the high speed relays. The next fault which was probably much closer to Plymouth Meeting was cleared in 8 cycles. The last disturbance on the Siegfried line was rather unusual, being caused by failure of the circuit breaker at Plymouth Meeting when the line was being opened. Some material jammed the oil valve connecting one of the switch tanks to the oil sys-

tem, so that before the breaker was opened most of the oil had drained out without being noticed. Naturally flashover to ground occurred inside the tank. This was equivalent to a 220-kv. bus fault at Plymouth Meeting and was cleared as expected by trip-out of all 220-kv. feeds into that station. This involved considerable time delay, but the system was not seriously disturbed probably because at the time Conowingo was carrying but very little load.

220-Kv. transformer faults. Several failures have occurred in the 220-kv. transformers at Plymouth Meeting and Conowingo as shown in Table III. Most of these failures have occurred in the windings, each failure involving only one phase. Synchronism has been maintained through all of these faults, although they were not cleared very quickly and in some cases the station was carrying full load.

Plymouth Meeting-Westmoreland line faults. Faults experienced on the Plymouth Meeting-Westmoreland 66-kv. lines are shown by Table IV. Since these lines carry most of the Conowingo output and have considerably higher percentage of reactance than the Plymouth Meeting-Conowingo lines, the matter of line faults is rather serious. Fortunately very few faults occurred there during the first three years when only two lines were in use. The first fault caused both lines to trip apparently due to the relay settings being too low. The next fault occurred when there was but little load on Conowingo, and synchronism was maintained. The remaining faults all occurred in 1931 after the third line had been added and after the new high speed switches and relays were in service. Most of these faults were unusually severe involving two and three phases, and in one case two lines; but they were cleared quickly and stability was maintained in every case.

Faults on interconnected system. Faults occur frequently on the Pennsylvania Power and Light Company system, particularly on the Wallenpaupack-Siegfried line.[8,9] However, none of these faults has caused instability at Conowingo even though a three-phase short circuit occurred at Siegfried while Conowingo was carrying full load. This fault lasted for about 52 cycles, reducing the positive sequence voltage at Plymouth Meeting to 76 kv. or about 60 per cent of normal. The maximum swinging of Conowingo power after the disturbance was from about 174 to 334 megawatts. This disturbance was far more severe than generally experienced with faults on the Pennsylvania Power and Light system which usually cause no power surges at Conowingo.

Faults on Philadelphia Electric main system. Faults on the Philadelphia Electric 66-kv. system excluding the Plymouth Meeting-Westmoreland lines usually cause but little disturbance at Conowingo. A large part of the 66-kv. system consists of single-conductor underground cable so that most of the faults involve only one phase. These faults sometimes last for more than one second, but there is seldom any trouble except burning of the cable and an occasional tripping of some synchronous motors and converters. A system of pilot wire protection is being installed to reduce the clearing time for cable faults.

One case involving a two- or three-phase fault on the Schuylkill-Chester 66-kv. aerial line in 1928 caused loss of synchronism in some of the machines at Conowingo as described previously. Other cases of two- or three-phase faults have developed on the 66-kv. system since the first year, but none of these has caused instability.

Conclusions

Based upon experiences with Conowingo hydroelectric station and with other parts of the Philadelphia Electric Company system described in this article, the following conclusions may be stated:

1. Faults on parts of the system other than the main lines from Conowingo have but little effect upon stability of that station.

2. Single-phase faults on the main lines from Conowingo have no serious effect on stability, but two- or three-phase faults under heavy load conditions are liable to cause instability unless cleared very quickly; faults of this type are likely to occur on the high voltage system.

3. Installation of high speed relays and circuit breakers on the high voltage system has insured the rapid clearing of faults; this practically eliminates the danger of instability except possibly for three-phase faults.

4. System stability may be calculated with sufficient accuracy for all practical purposes, and such studies are essential in system design.

Table IV—Faults on Plymouth Meeting-Westmoreland 66-Kv. Lines

Year	1928		1931								
Date	6–5	7–1	5–16	7–14	7–14	7–14	7–14	7–14	7–14	7–14	8–10
Time	10:18 p.m.	7:28 a.m.	3:53 p.m.	7:47 p.m.	7:49 p.m.	7:52 p.m.	7:57 p.m.	9:03 p.m.	9:14 p.m.	10:06 p.m.	5:58 p.m.
Cause	Ltng.	Short circuit	Short circuit	Ltng.	Ltng.	Ltng.	Ltng.	Ltng.	Ltng.	Ltng.	Ltng.
No. phases faulted	2	3	1	3	3	‡3	1 or 2	2	3	3	1
Miles from Ply. Mtg	5	0	0	4	2	3	1	3	1	1	1
†Pos. sequence kv., Ply	—	—	125	117	92	—	—	—	—	—	110
*Residual amperes, Ply	—	—	Open	—	750	—	—	—	—	—	7,620
Clearing time, Ply. (cycles)	—	Open	Open	18+	17+	—	13	—	—	7	12
Clearing time, Westmld. (cycles)	—	—	16	—	—	—	7	—	—	13	15
Load, Conowingo	180	98	255	202	202	202	202	226	226	168	42
Load, P. E. steam gen	55	35	47	186	186	186	186	255	255	150	335
Load, P. E. system	252	116	294	388	388	388	388	473	473	322	379
66-kv. system set-up	Solid	Solid	Solid	Split	Split	Split	Split	Split	Split	Split	Split
Conowingo stability	Tripped	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Conowingo power swings after fault cleared	—	—	235–290	165–280	140–322	—	—	—	—	—	None

*Measured in faulted line. †Equivalent line to neutral voltage; normal value 127 kv. ‡Double line fault. All load and power values in megawatts.

5. Much credit is due the manufacturers for the development of practical methods of studying stability, and for the production of equipment for improving operating stability.

6. Short-circuit tests on the system and special tests on equipment such as that used to obtain high speed excitation fully justify the expense incurred.

7. Permanently installed automatic oscillographs are desirable for: (a) investigating and analyzing conditions when instability occurs; (b) checking calculations of stability limits; and (c) checking relay operations.

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Automatic Combustion Control

Equipment for the automatic control of combustion in modern steam plants is installed as much to achieve operating speed and simplicity as it is to effect operating economy. Fundamentals of typical systems are outlined here.

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THE SUCCESSFUL application of automatic devices to power plant combustion control has been very largely a development of the past ten years. During this period confidence in automatic operation was greatly strengthened by its success in other fields, particularly in that of electric substations and hydroelectric generating stations. Moreover, because of the ever increasing urge for higher efficiencies and lower fuel and labor costs, its development and application has had whole-hearted approval and assistance of engineers and operators.

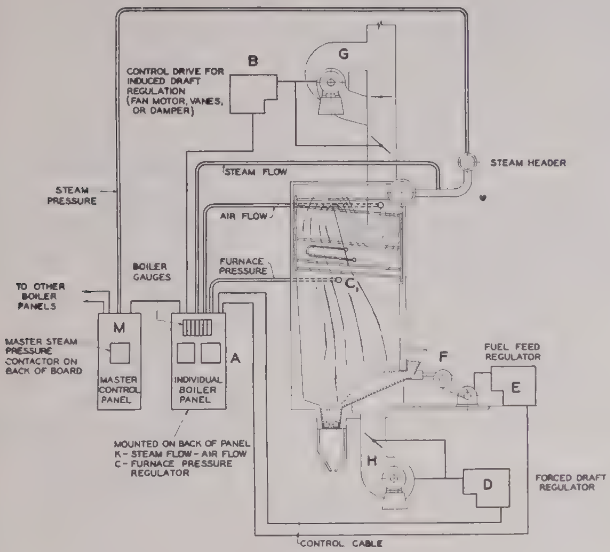
Earliest attempts at automatic control employed damper regulators actuated by steam pressure. Then, with the development of automatic stokers and forced draft, regulators were applied to blower engines and to the maintenance of balanced or nearly balanced furnace draft. This early apparatus was very crude in its mechanical features, and had the bad habit of being either all "on" or all "off," thus producing a steam pressure chart having frequent and wide fluctuations. The next step in the development was a departure from these unreliable automatic devices in the application of permanent instruments to indicate draft and rate of coal feed, together with better facilities for hand control. Where hand control of the entire plant was centralized, improvement was realized in the uniform loading of the various boilers and in the much closer regulation of steam pressure.

Development of a modern boiler plant necessitates the consideration of large units where, in many cases, the auxiliary equipment may be located a hundred feet or more from the control point. Also, large stokers may be used requiring varying air pressure in their different sections, or gas, oil, or pulverized fuel may be selected and for which efficient operation requires closely coordinated regulation of fuel and air. The necessary complement of gages and meters for a single boiler has been very greatly increased while economic necessity has reduced the number of men. The unit cost of labor and fuel has trebled in the last thirty years and consequently comparatively small savings in these items may justify the expenditure of material sums for new equipment to produce such results.

Another point is the fact that, because of the usually small amount of steam storage, fluctuations in station load almost immediately are reflected in steam demand. If maximum efficiency is to be maintained consistently these fluctuations in demand must be met by corresponding changes in fuel and air supply. When a multiplicity of boilers supply the same steam system, any change in station load normally should be properly

From "Automatic Combustion Control," (**No. 31-92**), presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

divided among all boilers. If the operating force is sufficient in numbers, highly skilled, and supplied with adequate instruments, results can be obtained with a well planned manual control which compare favorably with the best automatic control. However, the automatic control is ever alert to perform its functions. Its chief advantage lies in its ability to act simultaneously throughout the plant, thus permitting a reduction in the required number of skilled operators.



Bailey combustion control system

Large, modern boiler installations commonly are equipped with push-button type of remote control which represents probably the most easily and quickly manipulated type of manually operated equipment. The cost of such a system represents a large portion of the cost of a complete automatic control system, and it may be incorporated as a part thereof.

Adapting the Control to the Installation

While control systems can be adapted to most any type of boiler auxiliary equipment, the smoothness of operation often is complicated by the inherent characteristics of the apparatus controlled. The ideal combination of control and auxiliary equipment is one which, by delivering to the furnace a proportionately changed amount of fuel and air, gives immediate response to a change in demand. Some types of equipment inherently are capable of approaching this ideal more closely than others and an understanding of such characteristics will be helpful in an understanding of what may be accomplished with automatic control.

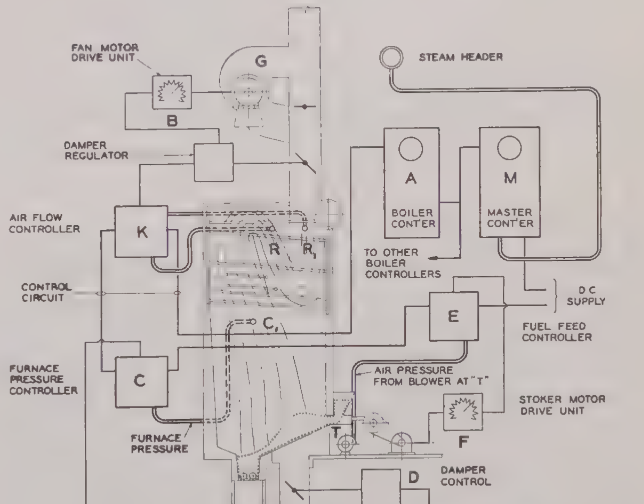
Air Supply. Air supply control usually is actuated by draft at the boiler outlet. Some types of draft-producing equipment can be controlled for smooth changes in small increments; others operate with large increments. Among the types of draft equipment producing smooth changes are:

1. Chimney draft—damper control.
2. Steam driven fans—driver control.
3. D-c. motor driven fans—driver control.
4. Wound rotor a-c. motor driven fans—driver control.
5. Single speed a-c. motor driven fans—damper control.

Among the types of dráft equipment producing abrupt changes of relatively large magnitude are:

1. Multi-speed induction motor driven fans—driver control.
2. Multi-speed induction motor driven fans—driver and damper control.
3. Multi-speed induction motor driven fans—driver and vane control.

Large, modern boiler installations employing long stokers commonly require a supply of air at several different points at different pressures. This condition makes necessary the provision of several windbox pressure controllers which may be adjusted either for a constant ratio or for varying ratios for the different sections of the stoker as conditions may demand. Similarly, pulverized fuel installations may require individual regulation of the primary, secondary, and tertiary air pressures.

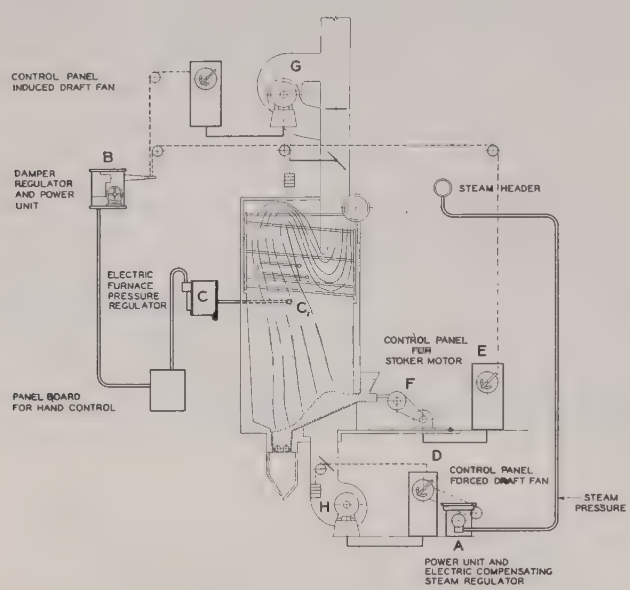


Leeds and Northrup combustion control system

In most systems of control involving the supply of air under pressure for combustion it is necessary to provide an auxiliary control to prevent the occurrence of a furnace pressure above atmosphere. This control is actuated by furnace draft and usually functions

as an emergency or readjustment mechanism on the forced draft fan.

Many different types of automatic control are available for application to the different systems used for producing draft or air supply. For example: in natural draft installations the automatic control is usually applied to the stack damper; for variable speed motors and steam turbines the speed of the driver only is automatically controlled; in some pulverized fuel systems employing a unit system, it is necessary to introduce a time lag in the air supply equipment to allow for the interval between the increase or decrease in the coal supply to the mill and the time when this change in supply reaches the furnace.



Enco combustion control system

Air Measurement. In a few cases it is possible to measure the air supply by means of an orifice or some other metering device installed in the air supply line. However, and usually because appreciable quantities of air enter through openings in the furnace setting, it is necessary to base the air control on the flow of the gases of combustion rather than upon the air supply. The medium most often used for this control is the pressure drop through a bank of boiler tubes. When the tubes are reasonably clean this method of air control is sufficiently accurate for all practical purposes. When the tube bank becomes partially covered with slag, manual readjustment of the air supply controller is necessary unless an additional control connection is made with some form of CO_2 meter to provide automatic readjustment.

Fuel Supply. Types of fuel supply equipment have a very marked influence on the quickness of response to a change in load and on the effect of large abrupt changes in draft on combustion conditions. The following types of supply equipment afford immediate response:

1. Gas.
2. Oil.
3. Pulverized coal—bin and feeder system.
4. Stokers carrying a heavy fuel bed.

The following types have a slow response (from one to fifteen minutes):

1. Pulverized coal—unit system.
2. Stokers carrying a light fuel bed.

All types of fuel supply are adversely affected by large, abrupt changes in air supply; the disturbance in all cases being more marked with water-cooled furnaces than with refractory furnaces. The effect on some of the more widely used systems is as follows:

Conditions	Effect
1. Stokers with deep fuel bed	Smoke and temporary loss in efficiency
2. Stokers with light fuel bed	Blowing bare spots on grates, loss in efficiency and capacity over a considerable period
3. Pulverized coal—bin and feeder system	Possible loss of ignition
4. Oil and gas	Possible loss of ignition
5. Pulverized coal—unit system	Probable loss of ignition

Fuel Measurement. Where coal is the fuel, the measurement of supply commonly is derived from the revolutions of the fuel feeding mechanism, each revolution of which is assumed to inject a given quantity of combustible material into the furnace. Unfortunately, however, coal is one of those natural products subject to wide variation in physical and chemical characteristics which variations are reflected in the fuel value per unit of volume. Consequently, correct ratio of fuel and air can be maintained only by occasional manual readjustment of the coal feeding mechanism or by an automatic air adjustment mechanism actuated by a CO_2 meter or a steam-flow air-flow meter.

Sequence Interlocking of Control. In nearly all large modern boiler installations it is necessary to provide sequence interlocking between certain of the control points. For example: it is usually necessary that a shut-down of the induced draft fan simultaneously interrupts the coal feed and air supply, and that the coal feeding mechanism will not overtravel beyond the ability of the induced draft fan to take away the products of combustion. In many installations firing pulverized fuel there is a low limit of coal and air feed below which combustion becomes unstable and the fire may blow out.

Wherever automatic combustion control is applied, each boiler unit is provided with a simple and ready means for changing from automatic to hand control as may be necessary under such emergency conditions

as the whole or partial interruption of the supply of coal, air, or feed water to an individual boiler.

Control-Power Supply. To insure continuity in the operation of the control system, the supply of the medium through which the control impulses are carried to the various regulators must be safeguarded positively by the provision of two or more independent sources of supply and a ready means of changing from one source to another. Pneumatic and hydraulic systems originally were employed, but with the advent of electrically operated remote control, electricity has been adopted by many manufacturers as the medium for automatic control. These electrical control drives are designed to use either alternating or direct current at any voltage from 110 to 250.

Systems. Probably no two power plants ever built were exactly alike. Comparison of any one with another as regards the detailed requirements of an automatic combustion control system reveals a surprising lack of standardization. Naturally the same is true of the control systems employed, and therefore only a generalized performance specification together with diagrams of several typical systems will be given here.

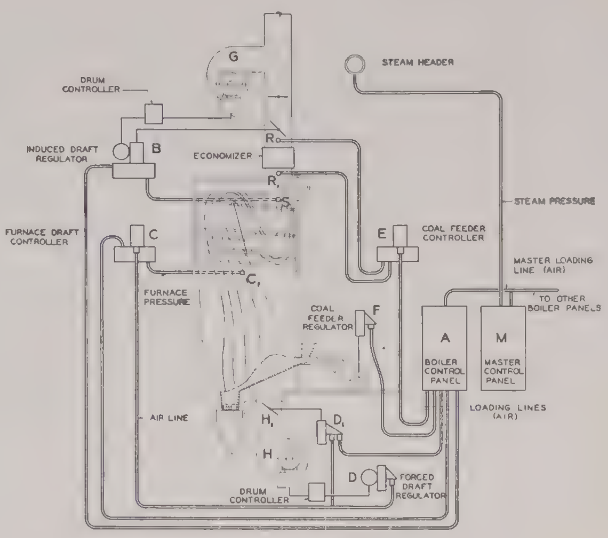
In all systems impulses actuated by variations in steam pressure are transmitted simultaneously to the various individual boiler control panels from which radiate the controls of fuel and draft. The control performance in general is as follows:

1. An increase in plant load causes an increased demand for steam and therefore a drop in steam pressure.

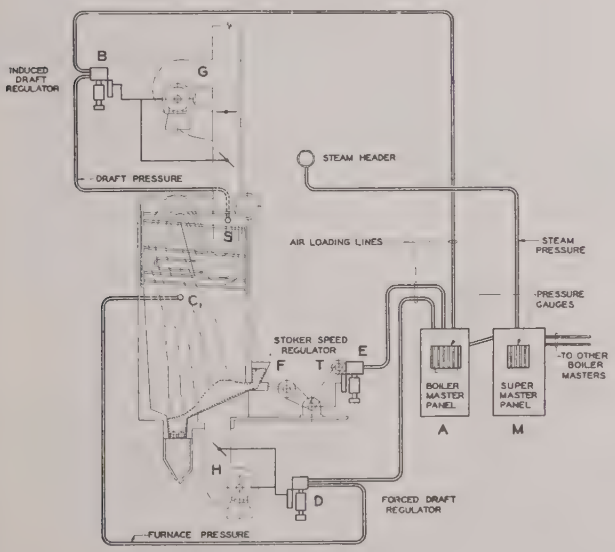
2. Changes in steam pressure are converted into impulses which actuate a regulating device controlling in proportion to the load the rate of fuel and air supply to the boiler. Forces or impulses which are not linear are adjusted in the regulator.

3. Since the regulator can control only mechanical forces which under normal conditions will supply the correct amount of fuel and air, variations from the assumed normal conditions must be compensated for by changing the relation between these mechanical forces which supply either fuel or air so that the correct amount of each is supplied to the boiler. A furnace pressure regulator and a CO_2 recorder will detect and make adjustments for variations from normal conditions. These variations are caused by slagging, damp coal, or an irregular supply of coal.

4. Controls can be set so that certain boilers maintain a constant output while other boilers take the variations, and can be provided with maximum and minimum stops to limit the range of output.



Hagan combustion control system



Smoot combustion control system

5. Control of any or all functions can be accomplished separately or in groups and either directly or indirectly as required by individual conditions.

6. Some of the available systems are provided with audible and selective visual signals to indicate equipment failure.

Conclusions

The question as to what financial return may be expected from an investment in automatic combustion control often is asked. The answer is infinitely more involved than the question. Savings in operating expense as high as 4 per cent have been reported. Rarely, however, has it been found practicable to make comparative efficiency tests on the same installation, operating with and without automatic control, to determine definitely the annual saving in operating expense.

As a rule, automatic control seldom is installed solely on the basis of a direct saving in operating expense. In fact its installation often is based mainly upon resultant operating advantages otherwise difficult or even impossible of accomplishment. Among the more important of these advantages are:

The uniform loading of all boiler units.

Instant response to changes in load.

The supply of fuel and air in correct proportions at all times.

A ready means of providing for safety of operation through sequence interlocking of auxiliary equipment.

Proposed Definitions of Power System Terms

DEFINITIONS of terms used in stability and interconnection studies have been developed by a special committee functioning since 1930. This subject committee was organized at that time under the auspices of the subcommittee on interconnection and stability factors of the committee on power transmission and distribution, to develop some definitions of terms used in stability studies. Later in the same year, a joint interconnection committee, with F.C. Hanker, as chairman, was formed with representatives from the committees on power generation, protective devices, and power transmission and distribution; and the work of the subject committee was continued under the direction of this subcommittee. Likewise, the scope of the definitions was increased to include terms used in interconnection as well as stability studies. The report of this work is submitted in five general divisions:

1. Interconnection terms
2. Stability terms
3. Active power and reactive voltampere conventions
4. Synchronous machine quantities
5. Response of excitation systems

In the preparation of this report, the subject committee reviewed the technical literature, particularly publications of the Institute, and consulted representative members of the committees of the Institute in order to obtain terms and their definitions which would be in accord with common usage and preferred practise in so far as possible. Attempt has been made to select terms which are descriptive of the subject. The general field covered by these definitions is indicated in the paragraphs following. It is hoped that all interested parties will become acquainted with these definitions and will express themselves freely on controversial points.

Interconnection Terms

In the symposium on interconnections presented at the A.I.E.E. summer convention in Asheville, N. C., June 1931, several interconnection terms were used for the various power quantities which may flow between interconnected power systems. It seems desirable at this time to propose definitions of these terms before too many loose expressions come into general use. In the report, therefore, definitions of terms are presented which are descriptive and cover practically the field in its entirety. The various types of active power and reactive voltamperes are defined.

Stability Terms

A number of papers with varying phraseology and a resulting confusion of terms have been presented before the Institute on the problem of stability of power systems. The subject committee has endeavored to reconcile the opinions of the several authors into a set of terms and definitions which will satisfy the requirements of power systems and the automatic devices used to control them. After consultation with several of these authors, definitions are recommended for the various stability terms.

Active Power and Reactive Power Voltampere Conventions

The convention of plotting active power and reactive voltampere quantities is somewhat arbitrary and does not depend upon a strict mathematical basis. The plotting of active power usually is taken as positive in the direction of power flow from a generator, but the plotting of reactive voltamperes has not been so obvious. To date, the international committee of the International Electrotechnical Commission, as well as the present subject committee have been unable to reach an agreement upon the convention to adopt. Meanwhile the subject committee presents an arbitrary choice to foster discussion with the understanding that this choice will not prejudice further action. The proposal consists of using the complex quantity $P - jQ$ to represent the active power and lagging reactive voltamperes such as supplied by an overexcited synchronous generator. There has been considerable discussion as to whether or not $P + jQ$ should be used because $R + jX$ represents an inductive reactance.

Synchronous Machine Quantities

Synchronous machine quantities are used in calculations for short-circuit currents, relay settings, stability studies, and the like. Both saturated and unsaturated values of these quantities are used in practise depending upon whether currents of very high value or of normal value are involved. The reactances as well as the time constants of synchronous machines are influenced by saturation. Since, in general, saturation effects have not as yet been sufficiently investigated to determine these constants for varying degrees of saturation, definitions are presented applying to any degree of saturation, and methods of determination by test applying to as great a degree of saturation as possible. Where alternative methods of test for reactances are given, care should be exercised in choosing the method for a particular application since they are not equally applicable for all degrees of saturation. A résumé is given of the methods of

Excerpts from "Proposed Definitions of Terms Used in Power System Studies" (**No. 32M2**), being the report of the subject committee on definitions, H. K. Sels, *chairman*, R. G. Lorraine, J. R. North, and C. F. Wagner, Jr., presented at the A.I.E.E. winter convention, New York, Jan. 25-29, 1932.

test for reactances, together with the degree of saturation which readily can be obtained. Attention is called to the added cost that may be necessary in making tests to obtain more accurate synchronous machine quantities for use in calculations of system operating conditions.

Response of Excitation Systems

The development of high speed excitation systems to improve the stability of power systems has created the necessity of expressing the characteristics of the exciter when used to overexcite the main machines. In the report, definitions are proposed which meet these requirements.

While many of the definitions proposed by the subject committee may be considered arbitrary, they have been considered in the best interests of the profession. General adoption of these terms and definitions will lead to a better common understanding with less possibility of confusion and controversy in legal and technical questions.

Engineering Supersedes Tradition

The engineer, having learned that action is best based upon the fullest and most accurate determination of facts possible, is said to be the type now needed by the world. This is the seventh article in The Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"

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MEN whose procedures have been based mostly on precedent and tradition have for many generations had the affairs of the world in their hands. We now discover that the views and methods developed by these men are inadequate in that they do not measure up to present requirements. While this condition was being reached a new group has developed which within recent years has altered greatly many of the things having to do with human life. I refer naturally to the engineers. I use the term engineer in a much broader sense than is frequently given it. To me a real engineer is a scientifically trained business man, but the scientific training is of a variety which leads him to *apply* the results obtained by scientists rather than to expand the fields of science.

This new specimen, the engineer, represents a new type of thought. He has learned that action is best based upon the fullest and most accurate determination of facts possible at the time and under the given conditions. He endeavors to hold himself clear of the influence of preconceived ideas, traditions, precedents, rules-of-thumb.

I am not able to prove that the engineer has been appointed by God to lead the world out of the situation into which it has slowly but surely brought itself. However, in studying the history of the human race, I have noticed that individuals and groups possessing particular aptitudes and/or trainings seem to appear at just about the time the world needs what they are equipped to furnish. If this be a fact, one might be justified in assuming that the recent rapid and widespread appearance and development of the engineer indicates that he is the type now needed to carry on human development or social development or culture or whatever else you choose to call it.

I am convinced of one thing: At the present minute the world is as much in need of individuals trained and willing to discover facts and to lead where such facts indicate, as it is of anything else. I am convinced also that, by training and habit of mind, the engineer is better able to undertake such a job than is any one other single group. By this I do not mean that I believe the engineer is capable of determining unaided all of the complex variety of facts that must be uncovered if we are to alter existing conditions greatly; I assume that he will have to call to his aid others skilled in special fields; but I believe he is best fitted to assemble and direct skilled fact-finding personnel and to intepret and apply the results of its work.

I am convinced also of another thing: No such radical change in the method of handling human affairs can occur overnight. Even those changes which appear to us as revolutionary in character, upon study, prove to be evolutionary. If we have now arrived at that place in our development at which we recognize the desirability of resting action on a factual basis, we are not going to jump from here to there in the twinkling of an eye. On the contrary, we are going to go our plodding way, experimenting, arguing, discussing, and more or less applying and accomplishing, until years or generations hence our successors will be controlling the affairs of humanity by this more rational method.

Editor's note: Pursuant to the invitation of The Engineering Foundation, the editors will be happy to receive comments, suggestions, criticisms, or discussions pertaining to this or other articles in this series.

A Self Stabilizing D-C. Welding Generator

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This new machine needs no external reactor, but employs a special field winding to compensate for resistance fluctuations in the welding circuit; it is completely self-contained and is self-excited. Provision is made for obtaining fine adjustments of current by simply shifting the brushes.

RAPID EXPANSION of arc welding in recent years has served in an ever increasing degree to focus attention upon the design and operating characteristics of arc welding generating equipments. Up until a few years ago the d-c. arc welding circuit invariably constituted a welding *system* rather than a welding *generator*. This applies even to the variable-voltage individual-operator sets as well as to the constant-potential multiple-operator equipments. Generally speaking, the so-called arc welding generator does not possess all of the characteristics required for arc welding and to compensate for this, external auxiliary devices of one kind or another are resorted to. The generator described in this article is designed to have inherently all of the characteristics required for arc welding without the assistance of any external auxiliary apparatus whatever, and therefore is in every respect an *arc welding generator*.

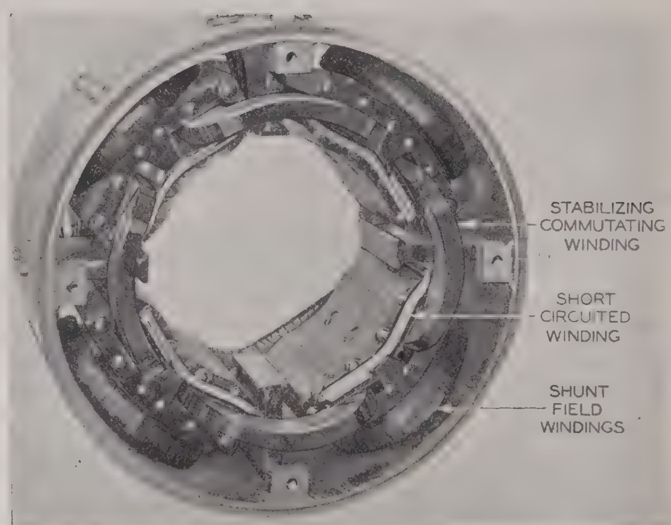


Fig. 1. Complete stator of self-stabilized arc welding generator with all field windings in place

Resistance Characteristics of Arc Welding Circuit

It is well known that the negative resistance characteristic of the arc makes it inherently unstable when operating from a constant potential circuit. To overcome this instability, the circuit must have a drooping volt-ampere characteristic; that is, the voltage must decrease with increasing current. Therefore individual-operator welding generators are designed to have a drooping volt-ampere curve. It is well known also, however, that when welding with a mild steel electrode, either bare or lightly flux-coated, the arc voltage drops to zero at more or less regular intervals whenever a drop of molten metal goes across the arc.

The time during which the arc remains short-circuited is quite short, being of the order of from 0.01 to 0.02 sec. Average time intervals between drops are approximately from four to five times the length of time on short circuit. The resistance of the metallic arc, therefore, varies rapidly between zero and a value which will make the potential drop across the arc at normal welding current equal to the normal arc voltage.

Variations in arc resistance resulting from metal transfer across the arc are much wider and much more rapid than those caused by the arc's inherent negative resistance characteristic. Because of the predominating character of these resistance fluctuations, the circuit to which an arc welding generator is delivering energy consists, from the standpoint of generating equipment, of a resistance which is periodically being short-circuited at a rate of from ten to twenty times per second.

Trend in Design

Importance of minimizing the momentary current fluctuations, or transients as they frequently are called, is discerned clearly in the most recent modifications in the design of arc welding generating equipments. Publications which have appeared lately on the subject indicate that considerable effort has been directed toward that end. For example, in some makes of apparatus the well known reactor which has been used extensively to smooth out the current fluctuations has been modified to utilize impulses from it to speed up the flux changes in the generator field. One such modifica-

Based upon "Recent Developments in Design of Arc Welding Generators" (No. 32-43) presented at the A.I.E.E. winter convention, New York, Jan. 25-29, 1932.

tion known as the "flexactor" has been described by Blankenbuehler (A.I.E.E. TRANS., V. 50, June 1931, p. 656-61) and another, the "transformer reactor," by Bergman (A.I.E.E. TRANS., V. 50, June 1931, p. 678-80). Apparently these modifications of the reactor have resulted in marked improvement in operation.

The desirability of eliminating the external stabilizer is recognized quite generally; however, to accomplish this requires that some means for stabilizing the arc be provided within the generator itself. On the basis of these and other known facts, then, it probably will be conceded that an ideal welding generator is one in which:

1. The external reactor has been eliminated, provided this has been accomplished without introducing undue complications.
2. Current impulses in the main circuit are reflected into the generator field to quicken magnetic flux changes and thereby make the machine more responsive to changes in the external resistance.
3. The exciter has been eliminated without resorting to a two-pole armature and four-pole field structure.
4. All regulating rheostats and switches have been eliminated without limiting the range or adjustment of welding currents.
5. Desirable arc characteristics are obtained over the whole range.

A generator which in the author's opinion fulfils these requirements now will be described briefly.

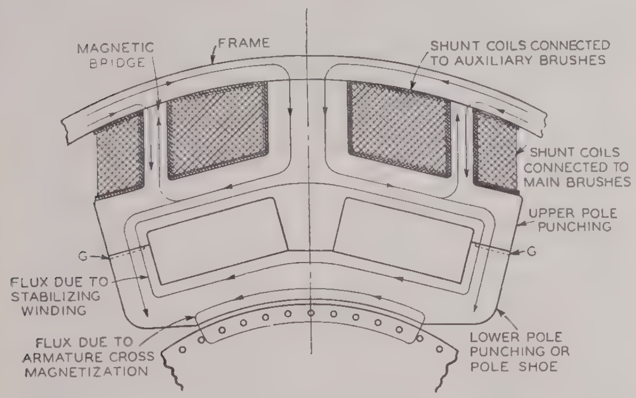


Fig. 2. Cross-section of generator main pole with the two shunt windings in place

Attainment of the first two objects enumerated has been made possible by a novel design of the commutating winding, shunt windings, and main poles; and by adding a special winding consisting of one turn short-circuited upon itself. The armature is similar to a standard d-c. armature, except that it is wound with a relatively large number of turns and has a correspondingly large number of commutator bars. In arc welding generators this is desirable for several reasons as will be shown in the following discussion.

With a large number of turns on the armature, it is recognized generally that a comparatively great change in the terminal voltage requires only a small change in the field flux; this makes the machine responsive to external resistance variations. With a high number of commutator bars, the volts per bar is low, which becomes a marked advantage in connection with the scheme of excitation to be described later.

In Fig. 1 is shown the field ring of the generator with all poles and field windings in place. It may be noticed that instead of being wound in the usual way on the commutating poles, the commutating coils have been extended to, and completely imbedded within, the main pole flanges. The commutating winding thus extended and surrounded by laminations functions as both a stabilizing and a commutating winding. The desired stabilizing effect thus is obtained without adding any windings to those ordinarily employed in commutating pole machines.

Method of assembling the pole flanges around the stabilizing winding can be observed readily from Fig. 1, assisted perhaps by reference to Fig. 2. As may be noticed, the pole is made up of two parts, the upper part being bolted to the generator frame. The stabilizing coil, which has been wound and formed to the proper curvature on a press, then is laid into slots in the upper part of the poles. Finally, the pole shoe is put in place and bolted to the upper part. This part of the pole serves as a common magnetic path for the stabilizing flux and the flux due to armature cross-magnetization.

From Fig. 2 can be noted also that the generator has two shunt coils separated by a magnetic bridge. The function of this arrangement and of the short-circuited winding is described in the discussion of an equivalent diagram of the electric and magnetic circuits. It may be pointed out here, however, that the axial length of the back of the pole—that is, the part bolted to the frame—is considerably shorter than the axial length of that part of the pole constituting the magnetic circuit of the stabilizing winding.

Excitation and Current Control

The well known reentrant volt-ampere curve of the shunt generator is not at all suitable for arc welding, since it is essential that the permanent short-circuit current be equal to or greater than the welding current.

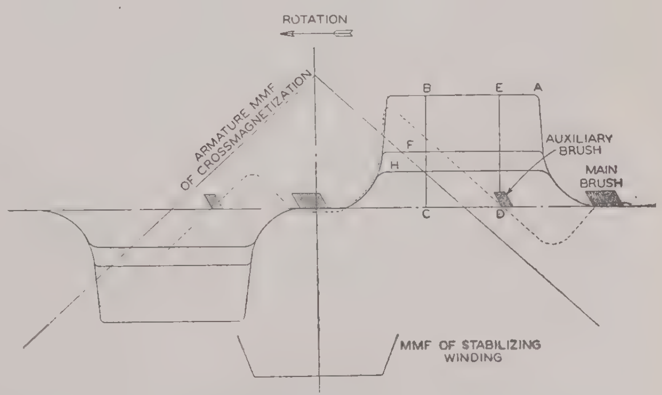


Fig. 3. M.m.f. diagram for two poles of generator. Note relative positions of main and auxiliary brushes

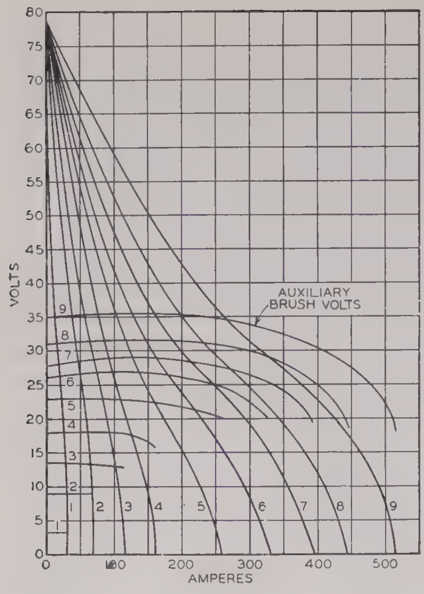


Fig. 4. Volt-ampere characteristics and auxiliary brush voltage for different brush positions

Main and auxiliary brushes are shifted together without altering their relative positions

For that reason some source of excitation must be available even on short circuit when the voltage across the main brushes is zero. Reference to Fig. 3 will show how this is accomplished.

In addition to the main brushes, the machine is equipped with two sets of auxiliary brushes spaced from 50 to 60 elec. deg. ahead of the main brushes. These excitation brushes have an unusually high contact resistance and can handle without commutation difficulties a much higher voltage per bar than ever is reached in these generators (which, as already pointed out, is unusually low). Line *A* represents the no-load field form, part of the negative portion of which is taken in by the auxiliary brushes. The voltage across the auxiliary brushes on open circuit therefore is proportional to the rectangle *BCDE*. The question that arises now is, "what will be the situation under some load conditions, for example, on short circuit?" First assume that magnetic saturation is negligible on short circuit so that fluxes are proportional to m.m.f.'s. Voltage in the shunt coil excited from the main brushes falls to zero on short circuit and the m.m.f. of this field is reduced to line *F*. In addition, a direct demagnetizing force from the armature reduces the m.m.f. on the field still further to line *H*. The remaining m.m.f.'s. are those due to the armature cross-magnetization and the stabilizing winding.

Distribution of flux in the air gap under the main poles is not affected directly by the m.m.f. of the stabilizing winding, but is affected indirectly by this m.m.f. when the pole shoe becomes saturated. Neglecting that for the moment, the flux distribution is the resultant of the net m.m.f. of the field and the m.m.f. of armature cross-magnetization. This is shown in Fig. 3 as a dotted line; the area included between this line and the base line, and lying above the base line, represents positive flux; similarly, the area below the base line represents negative flux. Thus upon short circuit, considerable positive flux still exists between the auxiliary brushes, whereas the net positive flux between the main brushes has been reduced greatly.

When the main and auxiliary brushes are shifted forward simultaneously, two phenomena become pronounced: The armature demagnetization is increased, and the voltage on the auxiliary brushes is decreased, both of which tend to reduce the current. Thus a wide variation in current can be obtained with a relatively small shift of the brushes. Actually the brushes are shifted by means of a micrometer screw arrangement, making possible minute gradations of welding current.

A set of volt-ampere curves of a 300-ampere welder is shown in Fig. 4. For the larger current values the voltage on the auxiliary brushes remains practically constant up to about normal current for that setting, and then drops off somewhat at short circuit. However, even at short circuit the auxiliary brush voltage is high enough to maintain a sufficiently large value of short-circuit current. For lower current values, the auxiliary brush voltage tends to remain substantially constant even at short circuit.

When the pole shoe, which as mentioned previously, carries the flux of both the stabilizing winding and the armature cross-magnetization, becomes saturated, the air-gap distribution and consequently the compounding of the auxiliary brushes are affected thereby. Saturation of the pole shoe can be modified, however, by introducing air gaps in the path of the stabilizing flux, as for example at points *G* in Fig. 2.

Momentary Current Fluctuation and Arc Recovery

To assist in forming a mental picture of the interactions between the various circuits during transient

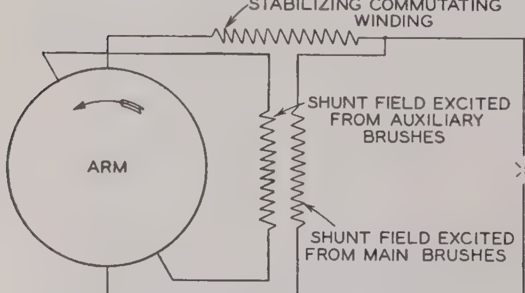
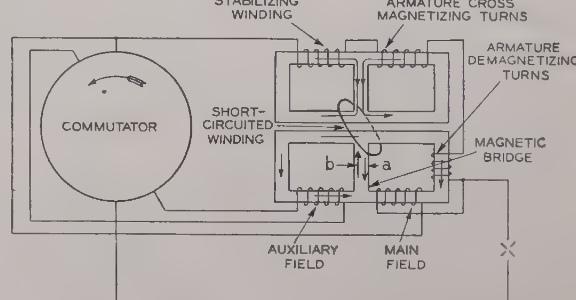


Fig. 5. Actual wiring diagram of welding generator without short-circuited turn (left)

Fig. 6. "Equivalent" diagram of generator and welding circuit (right)



conditions, an *equivalent* circuit diagram of the generator is shown in Fig. 6. It should be understood that this is not an actual diagram of the circuit (compare with Fig. 5) the separation of the armature cross-magnetizing and demagnetizing turns, for example, being for convenience only.

The stabilizing winding and armature cross-magnetizing turns are shown opposing each other with a common magnetic circuit, the pole shoe, between them. The armature demagnetizing turns are shown opposed to the two shunt fields and it should be observed that the flux within these turns is responsible for the voltage at the main brushes. The magnetic circuit, encircled by the auxiliary field winding, is the main pole body, and the magnetic bridge is interposed between the auxiliary field and main field windings. In the absence of saturation no mutual induction exists between the stabilizing and the two shunt windings, so they have been shown as having separate magnetic circuits.

The two shunt coils are excited in the same direction; however, unless the main pole body is saturated, but little flux passes through the magnetic bridge on open circuit and this in the direction indicated by arrow *a*. On short circuit the m.m.f of the main field winding disappears and an opposing m.m.f. of armature demagnetization appears. Now a large amount of flux passes across the bridge, but in the direction of arrow *b*; that is, instead of reducing the flux in the main pole body (which flux interlinks with the auxiliary field winding) almost

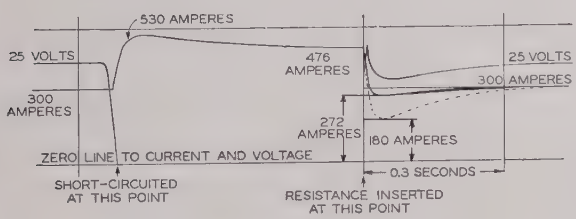


Fig. 7. Replotted oscillogram of test made according to U.S. Navy specifications on 300-ampere welding generator

Dotted line represents current drop and recovery time permitted by Navy specifications

all of it is diverted through the bridge. The result is that the energy stored in the auxiliary field changes but very little as the terminal voltage varies. Advantages of eliminating the necessity for changing the energy stored in this field when the external resistance varies, are obvious.

To make still faster the response of the machine to variations in the external resistance, the short-circuited winding is made to form a link between the stabilizing and the field windings. When the current in the stabilizing winding increases rapidly, a current will flow in the short-circuited winding which assists in reducing the field flux. When the current in the stabilizing winding is decreasing rapidly, the transient current in the short-circuited winding assists in building up the main flux. With this method of utilizing impulses from the arc circuit to speed up flux changes in the field, no high potentials are generated in any circuit at any time to subject the insulation to undue strain.

Some Tests on the New Machine

The A.I.E.E. test of a welding generator for momentary current fluctuation and arc recovery is as follows: Adjust generator on resistance load to obtain normal current at 25 volts; short-circuit one-half the resistance and allow current to settle; then suddenly open the short circuit and reinsert the resistance in the circuit.

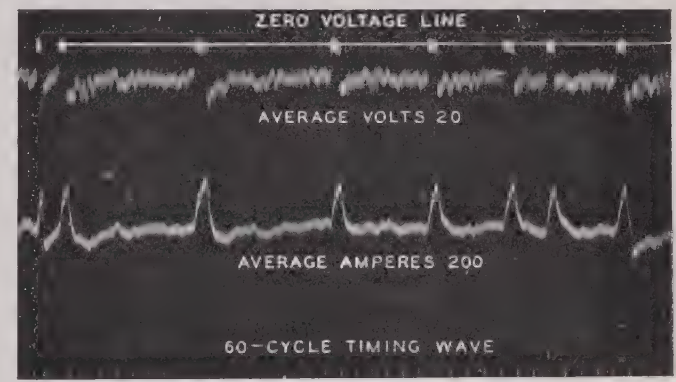


Fig. 8. Oscillogram record made during an actual welding operation with the new generator

The current momentarily drops below normal and the *time of recovery* is the time required for the current to return to within 5 per cent of its original value.

This test is of little value because the resistance variation is not wide enough to cause any noticeable depression of current below normal upon reinserting the resistance circuit; that is, not if the machine is worthy of being termed an *arc welding generator*. United States Navy specifications, however, call for the same test for arc recovery with the exception that all of the resistance must be short-circuited and then reinserted. This test means something.

A replotted oscillograph record of a test made according to the latter specifications at normal load on a 300-ampere welder of the type just described is shown in Fig. 7. The dotted line indicates the drop in current and the time of recovery permitted by the Navy specifications. It may be noticed that whereas the Navy permits the current to drop to 180 amperes, for this machine it actually drops to only 272 amperes. In Fig. 8 is shown an oscillograph record made when welding with a bare, mild steel electrode, and with an average welding current of 200 amperes and an average of 20 volts across the arc.

A Corona Tube Voltage Regulator

A corona tube may be used to regulate the output of a full-wave rectifier and therefore to control the excitation of a generator to give constant voltage. Performance curves for a five-kva. generator whose voltage is controlled by such a regulator indicate advantages over other types.

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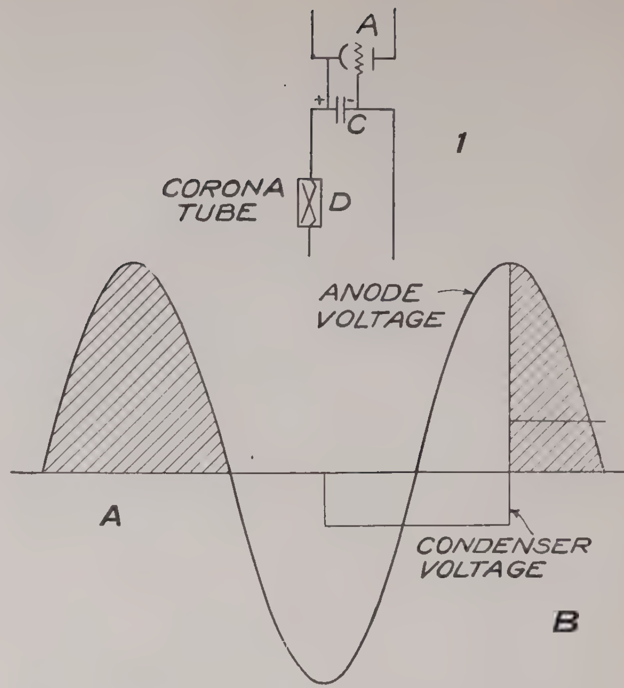

Fig. 1. Voltage wave and simplified circuit of corona tube and rectifying tube

A VOLTAGE REGULATOR consists essentially of a constant element; an element which varies with the voltage and which is balanced against the constant element; and an arrangement for using this balance to control the excitation of the machine whose voltage is to be regulated.

In the familiar vibrating contact regulator the modulus of elasticity of a spring is the constant element. Acting against the spring is the pull of a solenoid which is dependent upon the voltage. The forces due to the solenoid and the spring act on a plunger which operates a contact by which resistance is put into or taken out of the generator field circuit, thereby regulating the generator voltage.

The most serious disadvantages of the vibrating contact regulator are:

1. Wear and sticking of the contacts.
2. Periodic fluctuations of the voltage with opening and closing of the contacts.
3. Slow response to fluctuations of the voltage, due chiefly to the time lag of the field circuits of the exciter and the generator.

Recently a number of new types of regulators has been devised. Almost any phenomenon which varies with voltage may be made the basis of a voltage regulator, such as the saturation of an iron core reactor, the resistance of a conductor heated by the voltage, or the internal resistance of a thermionic tube whose filament is heated by the voltage. The regulator described below employs the critical voltage of a corona tube as the basic phenomenon.

The corona discharge tube employed consists of two symmetrical electrodes sealed into a glass tube containing an inert gas at a suitable pressure. Due to the fact that the tube contains a definite quantity of gas constrained to a fixed volume, the mean free path of an ion and therefore the corona voltage are practically independent of the temperature. Since ionization builds up very quickly at a voltage above the critical value, the breakdown voltage is also independent of the frequency, for frequencies within the commercial range. With the electrodes surrounded by an inert gas such as argon there is negligible disintegration of the electrodes during discharge; the breakdown voltage of the tube is constant and the life very long.

These characteristics of the corona discharge tube make its critical voltage suitable for the constant element in a regulator. The fact that it regulates to a constant peak voltage rather than a constant effective voltage is not a serious disadvantage, for the variation of wave form with load is not appreciable and there will therefore be a constant form factor.

In order to control the excitation of a generator we may use the charge passing through the corona tube above the corona voltage to bias the grid of a rectifying tube and thereby regulate the amount of rectified current which will be supplied to the generator field. Any type of rectifying tube may be used. However the high efficiency and large amplification factor of a gaseous tube, such as the thyratron, make this type of tube very desirable.

In order to explain the principle of operation, the simplified circuit shown in Fig. 1 will be considered first, and the voltage applied to the anode and cathode of the rectifying tube will be assumed to be in phase with the

From "A Corona Tube Voltage Regulator' (No. 31-112) presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

voltage in the corona tube circuit. The thyratron tube A has a negative grid characteristic, and it therefore normally conducts current into the field of the generator during the half wave when the anode voltage is positive, as indicated by the shaded positive half cycle. During the half wave when the anode voltage is negative the condenser C will be charged as indicated by the polarity marks, provided the circuit is connected with the proper polarity and provided the voltage rises above the critical value for the corona tube. During the first part of the next positive half wave the thyratron cannot conduct current because the grid is negative. However the grid bias will be reversed by the corona tube at the peak of the voltage wave, and the thyratron will conduct current during the latter half of the positive voltage wave as shown by the cross-hatched area. In this way the average value of the rectified current will be reduced to one-half the full half wave or maximum value when the voltage is above the breakdown value for the corona tube.

If a voltage is impressed on the corona tube which lags in phase behind the rectifier voltage, the average current may be reduced to less than 50 per cent of its maximum value because the grid bias will then be reversed after the peak of the voltage wave. When the corona tube is supplied from a voltage 60 degrees behind the rectifier voltage as in a three-phase machine, the corona tube will reduce the average current to 7 per cent of the maximum value.

The circuit as described above will vary the excitation by definite steps and will give fluctuations in the excitation just as are produced by opening and closing the contacts of a vibrating regulator. However if a leak is placed across the grid biasing condenser of a value such that the time constant CR of this condenser and leak is about equal to the period of one-half wave, then the grid condenser voltage may be reduced by leakage to a value where the thyratron will start. The time it will take to reduce the grid voltage to the starting value will depend on the initial charge of the grid condenser, and this is determined by the excess of the voltage above the critical voltage of the corona tube. Therefore the time of starting for the thyratron rectifier in any half wave will be delayed by an amount which is determined by the excess of the voltage above the breakdown voltage of the corona tube. This is indicated in Fig. 2. A small rise in total voltage above the critical value will serve to reduce the rectified current to about 7 per cent of its maximum value. However this change is continuous.

The circuit used for controlling a full-wave rectifier by means of a corona tube is shown in Fig. 3. It was found quite difficult to make corona tubes so symmetrical that they would break down at the same voltage on the positive and negative half waves. However by adding the condenser C_4 shown in Fig. 3 it is possible to eliminate any unidirectional components of current and cause the corona tube to have the same positive and negative critical values.

In the regulator used for the results given below, the thyratrons were too small to rectify the entire field current and their output was used for the field of an exciter.

In this case a further difficulty arose in the time

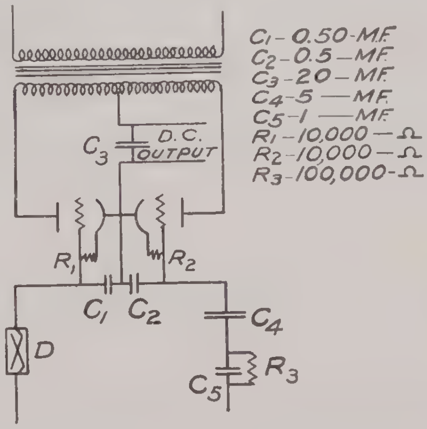

Fig. 3. Corona tube voltage regulator circuit for full-wave rectification

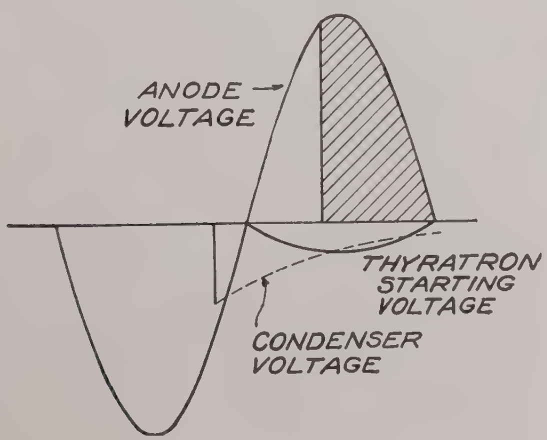

Fig. 2. Voltage waves with leak across grid biasing condenser

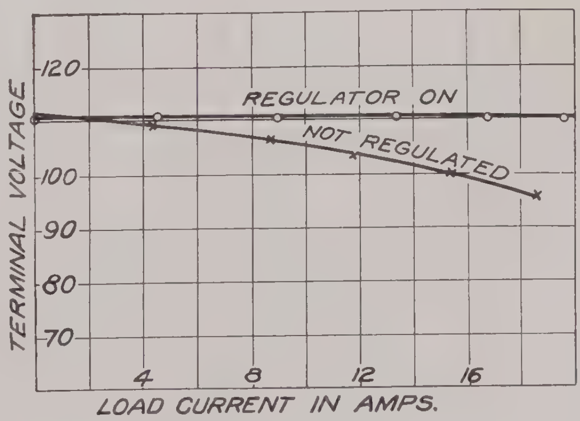

Fig. 4. Voltage regulation with variation in generator load

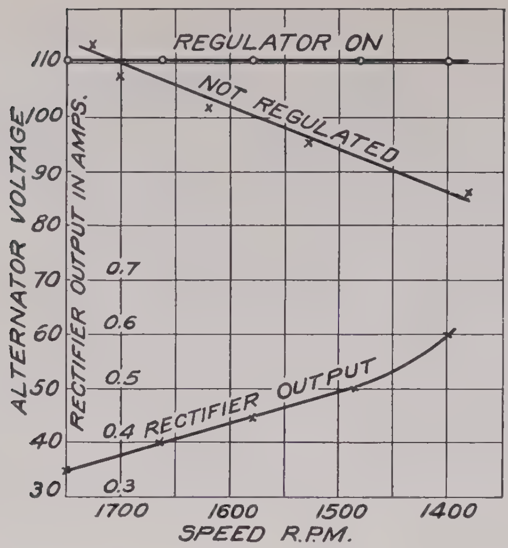

Fig. 5. Voltage regulation and rectifier output with variation in exciter speed

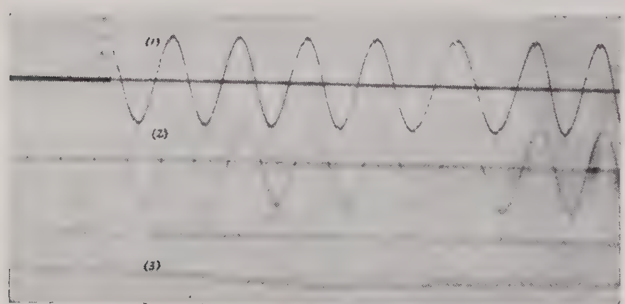

Fig. 6. Oscillograms of (1) load current, (2), alternator voltage, and (3) regulator output when suddenly applying full load to generator

lag of the exciter and alternator fields in responding to a change in the rectifier output. This caused oscillations of the generator voltage of about the period of the time constant of the field circuit. It was found possible to suppress these oscillations by introducing into the corona tube circuit a transient of about the same period as the oscillations. This transient is introduced by a condenser with a leak as shown at C_5 and R_3 of Fig. 4, such that C_5R_3, the time constant, is about equal to L/R, the time constant of the slowest field circuit.

The constants of the regulator circuit as used are shown in Fig. 3. The critical voltage of a corona tube with given dimensions and gas pressure may be predicted from the data giving the corona voltage of the gas to be used. The tube as used contained argon at a pressure of two centimeters of mercury. The electrodes were parallel wires 0.25 mm. in diameter and separated 1 cm. The critical voltage of this tube was approximately 350 volts peak value.

The results shown in the curves of Figs. 4 and 5 were taken on a five-kva. three-phase motor-driven alternator excited from a 110-volt motor-driven exciter. In the curves of Fig. 4 the effects of load variation are shown while Fig. 5 shows the regulation when the speed of the driving motor is varied. The oscillograms in Fig. 6 shows the transient conditions when full load was suddenly thrown on the generator.

This type of regulator would employ the same methods of compounding and line drop compensation now in use. It is believed that the simplicity, compactness, high sensitivity, and quick response of this corona tube regulator offer advantages over the other types.

Photoelectric Recorder Has High Sensitivity

A new recorder has been developed which employs for the measuring and recording operations separate elements coupled together by a combined optical and photoelectric system. Tests show that the new instrument is as accurate, sensitive, and responsive as a good indicating instrument.

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As SOON AS an instrument is developed which is capable of *indicating* the value of any quantity, attempts usually follow to make its function partly automatic by having it *record* its readings. Ordinary direct-acting recorders are the heavier and higher-torque counterparts of corresponding indicating instruments; although such recorders have some highly desirable characteristics, such as rapid response and the furnishing of a continuous record, their sensitivity cannot be made to approach that of indicating instruments. In other cases it is desirable to utilize the instrument for controlling the indicated quantity. These additional requirements involve the performance of mechanical work but in many cases the necessary additional energy is not available from either the instrument or the mea-

Based upon "The Photoelectric Recorder" (No. 32-15) presented at the A.I.E.E. winter convention, New York, Jan. 25-29, 1932.

sured circuit. Thus in the past the application of indicating instruments to recording and control operations has not been possible beyond certain limits.

The photoelectric recorder described in this article combines all of the advantages of direct-acting recorders with those of the most sensitive indicating instruments. This is accomplished by providing a separately excited recording element to do the actual work of making the record. A sensitive indicating instrument controls the position of the recording element so that the record obtained represents the readings of this basic instrument. The loss in the sensitive basic instrument is the only power required from the measured circuit.

A combined optical and photoelectric system is utilized to link together the basic and recording elements of this new instrument. The basic element itself rotates a galvanometer mirror through an angle corresponding to its reading, and can be made even more sensitive than the usual indicating instruments of the pointer type. Furthermore, the recording element may possess as much torque as required and be made as heavy and sturdy as desired without affecting the basic element or measured circuit in any way. As a result, the photoelectric recorder possesses all of the desirable characteristics of direct-acting recorders, and at the same time is capable of a sensitivity and a rapidity of response equal to that of the highest sensitivity indicating instruments.

An interior view of this new recorder is shown in Fig. 1. The instrument is completely self-contained and requires only an auxiliary power source of 115 volts, 60 cycles; it is available for either portable or switchboard use. Internal parts of the recorder may be grouped into five units: (1) the basic indicating instrument or galvanometer; (2) the optical system; (3) the recording element; (4) the chart carriage; and (5) the power unit.

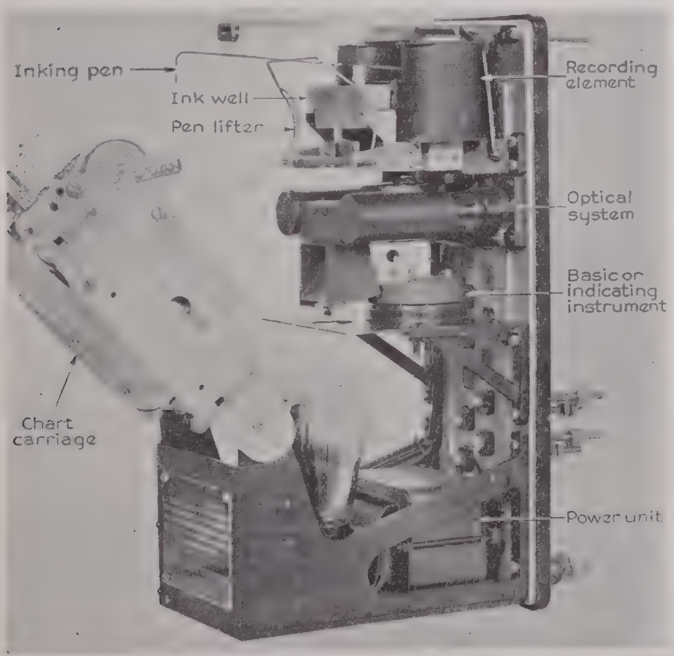

Fig. 1. Interior view of one type of photoelectric recorder with chart carriage tilted out

The basic instrument is the only *measuring* device within the recorder. It may be similar to almost any ordinary indicating instrument or galvanometer element, but the particular basic instrument used determines the sensitivity and rapidity of response of the resulting recorder.

A schematic diagram of the optical system may be seen in Fig. 2. In general this arrangement comprises a group of reflectors so arranged that an angular displacement between the recording and basic elements will cause a shift in light distribution between the photoelectric tubes, which in turn reacts on the recording element to reduce the displacement to zero. Thus the optical system acts to maintain the recording and basic elements in the same angular position at all times. How this is accomplished may be determined by inspection of Fig. 2. The important reflectors are: the basic element mirror A, the curved reflector B, recording element mirror C, and finally, the dividing reflector D.

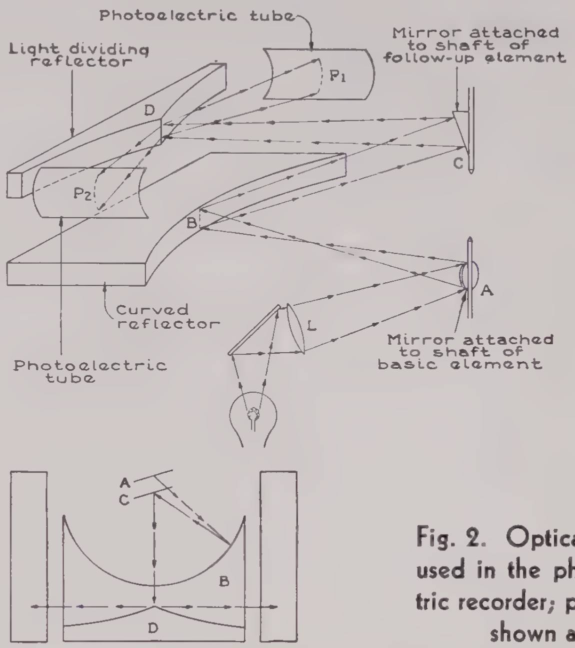

Fig. 2. Optical system used in the photoelectric recorder; plan view shown at the left

The recording and basic elements usually are mounted on the same axis, or very nearly so, although this is not necessary for successful operation of the instrument. The lamp and condensing lens converge a beam of light upon the basic element mirror A from which it is reflected to the curved mirror B. The point where the light strikes mirror B will depend upon the angular position or "reading" of the basic element, but regardless of where it strikes B it is reflected to mirror C attached to the shaft of the recording element. From C the beam is reflected to D at an angle depending upon the angle of reflection from B and also upon the position of the recording element. When C and A are parallel, however, the light will split evenly upon the dividing edge D; this

holds regardless of the actual positions of A and C so long as they are parallel to each other. If they are not in this parallel position, the light will strike to one side of the edge of D; more of it thus will pass into one photoelectric tube than into the other and cause the recording element to turn until A and C are parallel. Relations between the various angles of incidence and reflection are shown in the plan view shown in the lower right hand corner of Fig. 2; by slightly displacing the mirrors from their true positions, the different paths of light can be traced readily.

Power to operate the recording element is controlled by the photoelectric circuit (See Fig. 3). Of greatest importance is that part of the circuit beyond the field coils of the recording element. A portion of the d-c. voltage across the field coils is applied to the three-element pliotron tube; the plate current of this tube passes through the recording element armature connected in the filament side of the circuit to permit grounding one armature lead. Another portion of the voltage across the field coils is applied to the two vacuum type photoelectric tubes which are connected in series with their common junction connected to the grid of the pliotron.

This circuit possesses very high sensitivity to changes in the distribution of illumination between the two tubes so that the slightest unbalance of light in either direction between the tubes will throw the grid voltage to one extreme; a slight unbalance in the opposite direction will throw the grid voltage to the opposite extreme. These extreme grid voltage swings occur far too fast

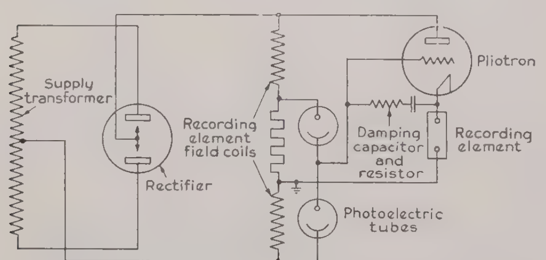

Fig. 3. Photoelectric circuit for controlling the recording element

under normal conditions to make the circuit useful for purposes of recording. However, the response of the circuit may be made as slow as desired without sacrificing the high sensitivity and its obvious advantages. This is accomplished by inserting a capacitor and resistor in series between the grid and filament of the pliotron tube. With these added to the circuit it is necessary to alter the charge upon the capacitor before the grid voltage can change, and the time lag of this procedure may be adjusted to any degree by changing the value of the capacitance. Without the damping capacitor and resistor violent hunting would take place between the recording element and the photoelectric circuit, whereas with the damping circuit in use, all tendency to hunt or overshoot can be eliminated completely.

The recording element may be any ordinary sturdy unit which will produce sufficient torque from the output of the pliotron tubes. Likewise the inking system and chart carriage may be of conventional design.

Accuracy

In any new instrument all possible sources of error should be investigated carefully. The mere mentioning of a possible source of error, however, should not be interpreted in any way to mean that that particular source is an important one; in fact all known factors which might affect the accuracy of the instrument are mentioned mainly for the purpose of showing how extremely small are their possible effect.

Variation in the supply voltage does not affect the accuracy of the photoelectric recorder within rather wide limits. Voltage changes are automatically compensated for by corresponding changes in the recording element current and thus produce no discernible effect upon the record. Changes in vacuum tube characteristics also are automatically compensated by the circuit in the same manner as are voltage fluctuations. Changes in lamp illumination caused by variations in the supply voltage, deterioration of the filament or blackening of the bulb, ordinarily do not produce any effect upon the recorder during the life of the lamp. Changes in illumination also may result from the reflectors becoming dusty or fogged. These variations in illumination may cause a noticeable slowing down of the operation of the instrument but do not affect its accuracy in any way.

Variations in photoelectric tube sensitivity may be cited as another possible source of error. Proper design of the optical system however has reduced the effect of such changes to a secondary and negligible order of magnitude. It has been found that errors due to this cause are limited at most to a few tenths of one per cent, and this only after a considerable period of time. Resetting the instrument on zero at occasional intervals would eliminate the possibility of even this small error. Other possible minor sources of error include vacuum tube grid currents, photo tube dark currents, and leakage currents in the grid circuit. All of these tend to react in the same manner as changes in the photoelectric tube sensitivity. The magnitude of all stray currents, however, may be reduced without difficulty to from one-tenth to one-twentieth of the actual control current, so that the effect is entirely negligible.

Upon the basis of the foregoing it may be said that a photoelectric recorder is practically self-compensating for all normal changes in supply voltage, lamp illumination, and vacuum tube and photoelectric tube characteristics. Tests made so far indicate that this recorder has a sustained accuracy over long periods in the same order of magnitude as would be expected from a high grade indicating instrument.

The Kindling of Electric Sparkover

Experimental evidence is presented which tends to prove that electrons and not protons or positive ions are the active carriers in the spark kindling mechanism and that Lichtenberg figures form the initial step in the process.

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ELECTRIC SPARKOVER and the kindling mechanism by which it takes place recently has become the subject of much discussion. Results of investigations already made furnish ample evidence that the process is extremely complex and that the speed of formation is in the order of 10^8 cm. per sec. instead of 10^4 or 10^5 as previously thought. Many factors such as polarity, shape of electrodes, ionization, space charges, voltage gradients, air pressure, and temperature, also are known to affect the process. Although previous investigators have been able to throw some light upon certain phases of the initial or kindling stage a comprehensive explanation of the complete process still is lacking.

The investigation described in this article presents a new method of approach to the problem and the results furnish additional information concerning the kindling period, that is, the first few microseconds of the sparkover process. Apparatus used in the tests has been described previously (A.I.E.E. TRANS., Vol. 49, 1930, p. 1384). It consists essentially of a specially designed air-tight photographic plateholder (see Fig. 1) which is placed in the field of a powerful electromagnet. Voltage impulses forming the Lichtenberg figures are impressed upon two electrodes the ends of which are held in contact with the sensitized surface of the photographic plate. The apparatus is arranged so that the field of the electromagnet is at right angles to the plate the desired pressure inside being maintained by means of a vacuum pump connected as shown. To simplify the discussion and particularly any references to illustrations, the direction of the magnetic field will be designated by the letters S and N, S indicating that the plate-holder was placed in the field so that the south pole is in front of the printed page, and N indicating the reverse.

A graphical representation of the path which an electron would follow on the emulsion surface of the plate in passing from the negative to positive electrodes under combined stress of dielectric and magnetic fields is given in Fig. 2, direction of the magnetic field being assumed as S.

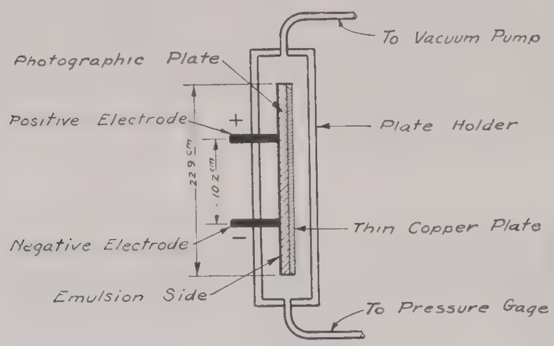

Fig. 1. Cross-section of air-tight plate-holder

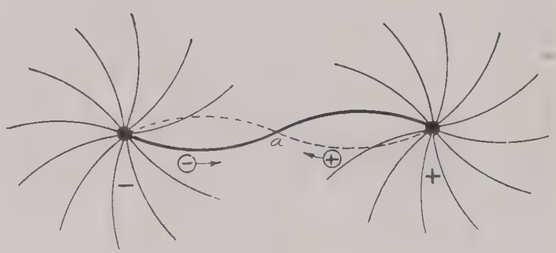

Fig. 2. Graphical representation of electron and proton paths between two electrodes under the combined stress of dielectric and magnetic fields

Consider an electron projected from the negative electrode under the given conditions and passing through the point a midway between the two electrodes. The electrostatic force of repulsion from the negative electrode and attraction to the positive electrode combined with the reaction from the magnetic field at right angles to the direction of motion, will cause the electron to move along a path similar to that indicated by the solid line. It is evident that under the combined action of the dielectric and magnetic fields the paths of *all electrons falling into the positive electrode* will move in paths bending in the counterclockwise direction, with reference to the positive electrode. Hence, if *electrons* be the active elements in the sparkover process the path followed by the spark should have a double inflection as illustrated by the full line in Fig. 2. On the other hand, if positive ions or *protons* be the active elements in the sparkover mechanism the path followed by the spark likewise should have a double inflection, but must be curved in the reverse direction, as indicated by the broken line in Fig. 2.

From "The Kindling of Electric Sparkover Based on Lichtenberg Figures," (No. 31-123) presented at the A.I.E.E. Pacific Coast convention, Lake Tahoe, Calif., Aug. 25-8, 1931.

Deflections of the sparkover path therefore can be used as a criteria in determining whether electrons or protons are the active elements in the sparkover process.

On the basis of the foregoing discussion consider the three sparkovers recorded in Fig. 3. In *b* the field direction was *S*, the same as used for the diagram in Fig. 3. The sparkover path has a double deflection exactly like that of the solid line curve in Fig. 2. In *a* and *c* the direction of the field was *N*, that is, reversed as compared to the direction in *b*; deflection of the sparkover paths in *a* and *c* also are reversed as compared to *b*. It is evident therefore that according to the argument advanced in the preceding paragraph, electrons were in each case the active elements in the kindling stage.

By reducing the air pressure within the plate-holder the bending effect of the magnetic field is increased, and deviation of the sparkover path from a straight line increases proportionately. A series of sparkover photographs accordingly were taken at air pressures ranging from atmospheric to 0.02 mm. Hg. The double inflection of the curve, in each case, followed the path that would be taken by negative charges, that is, electrons, as illustrated in Fig. 2 by the solid line.

The sweep of the nebulous positive figure, when formed at low air pressure and under the stress of the magnetic field, is revealed in Fig. 4. The double inflection of the sparkover path, arrested before complete sparkover occurred, is very marked, and is in complete accord with the analysis of the electron path (solid line) indicated in Fig. 2. There is no evidence of a counter flow of positive ions or protons in either this or any of the other photographic records.

Conclusions

Although the number and range of experiments made on Lichtenberg figures on sparkovers formed under stress of magnetic fields are limited, the results obtained together with the many important relations previously determined seem to warrant the following observations:

1. Lichtenberg figures represent, or are formed by, elementary electric sparks. On this basis the process of formation of these figures would represent also the kindling mechanism of the simplest form of sparks.

2. Lichtenberg figures or the electric sparks producing them form the initial step in the sparkover process.

3. Sparkover develops from the tips of the positive Lichtenberg figures and tends to follow the positive and negative streamers.

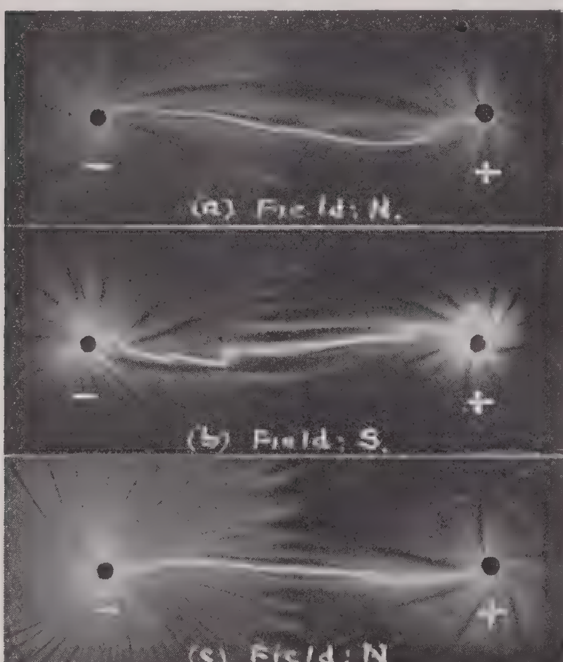

Fig. 3. (Above) Lichtenberg figures and sparkover paths for three cases

Air pressure,—15 cm. Hg.
Field,—12,500 lines per sq. cm.
Electrode spacing,—5 cm.

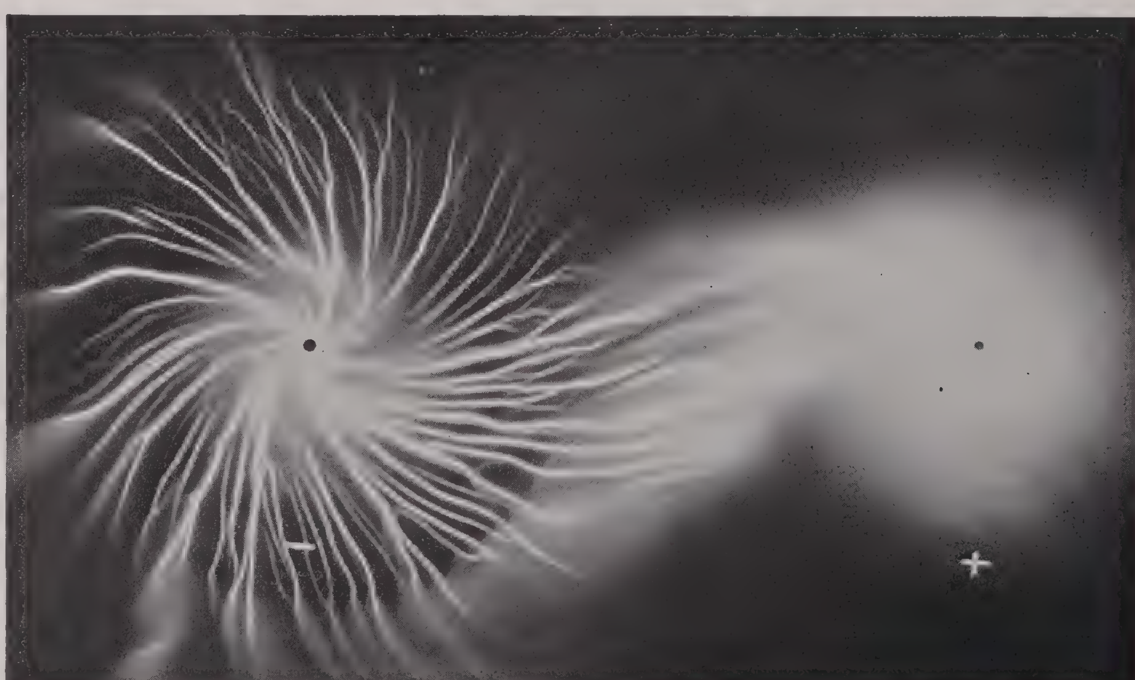

Fig. 4. (Right) Typical Lichtenberg figures of arrested sparkover at low pressure

Air pressure,—1.3 cm. Hg.
Field,—S, 5,160 lines per sq. cm.
Electrode spacing,—10.2 cm.
1 megohm resistance in series with gap

Reestablishing Excitation of a Loaded Alternator

Operating tests on large turbine-generators indicate that following the accidental opening of the field switch of a loaded machine, service should be restored by closing this switch as soon as possible, without removing the generator from the bus.

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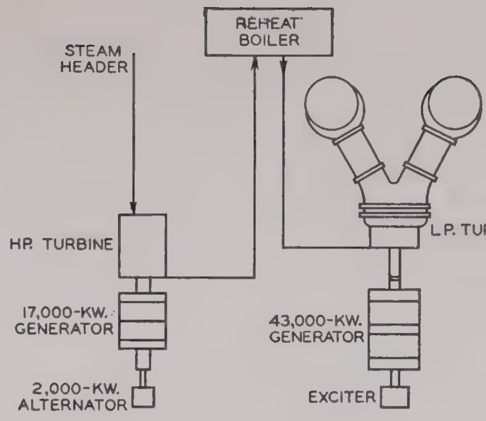

Fig. 1. Plan of two-element 60,000-kw. turbine-generator unit No. 2 at Crawford Ave. station

SWITCHBOARD operators in generating stations are at times suddenly confronted with troubles which call for immediate action. Such a situation results with the unexpected opening of the field switch of a loaded generator, and the operating rules of different power companies are by no means in agreement as to the proper procedure in this emergency.

In an attempt to determine exactly what happens when the field switch of a large alternator is opened and a short time later reclosed, a group of tests was conducted. The most interesting of these tests is illustrated by Fig. 2 which is a faithful reproduction of oscillograph records. These were taken on the cross-compound 60,000-kw. 60-cycle 12,000-volt unit illustrated in Fig. 1. The high pressure generator is rated at 1,800 r.p.m. and has 5.8 ohms synchronous impedance, while the low pressure generator is rated at 1,200 r.p.m. and has 1.92 ohms synchronous impedance. The external reactors between the unit and the bus are 827-kva., 3,500-ampere, and have 3 per cent reactance at 12,000 volts.

As illustrated in Fig. 2, the machine was carrying 50,000 kw. at 80 per cent power factor lagging when the switch was opened. The total load lost following the opening of this switch was 40 per cent. Root-mean-square values of armature current and voltage are shown, the field current and turbine speed being instantaneous values.

The action of both units of the machine is evident from the oscillograms. Upon opening the field switch, the generator field was short-circuited by discharge resistors and the field currents of each unit almost immediately dropped to less than half value. Then for a period of four seconds the fields gradually became demagnetized, the station bus voltage dropped, and the armatures gradually drew heavy magnetizing currents from the system. Following this and until the field switch was reclosed, transient conditions existed with both machines running considerably above synchronous speed. The speed of the high pressure turbine was very erratic and violent governor action was observed. The low pressure turbine, not having a speed regulating governor, ran at a more uniform speed. A further reason for the steadiness in the speed of the low pressure turbine can probably be found in the fact that the reheat boiler served as a stabilizer for the rapidly pulsating steam that was passing through the high pressure turbine. Since the heat in the reheat boiler was constant it momentarily would give off more reheat to a smaller amount of steam at a lower pressure, and less reheat to a larger amount at higher pressure.

As the magnetic coupling between the field and the armature poles was removed on the opening of the field switch, the energy produced by the turbine accelerated the machine above synchronous speed. The field winding then cut lines of force and had induced in it a current which had a frequency proportional to the slip; that is, the difference between the armature speed and field speed. The general characteristics of the machine were those of an induction generator. The governor on each machine prevented it from reaching an excessive speed, and the necessary exciting current was drawn from the line.

As indicated by the oscillograms the field currents reversed each time a field pole passed over an armatures pole. The armature currents plotted as r.m.s. values are seen to have a maximum and a minimum value for each reversal of the field current. Ordinarily an induction generator would have constant armature current for a given speed. The peak values found on these tests may be explained by the fact that the field does not have a uniformly distributed winding such as would be found in the rotor of an induction machine.

Whether or not the shunt wound exciter would have

Based upon "Reestablishing Excitation of a Loaded Alternator in Parallel with Others" (**No. 31-101**) presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

become demagnetized if the field switch had been closed when the induced field current was a maximum in the reverse direction was not definitely determined. However, in the worst case found in these tests the low pressure field was 550 amperes in the reverse direction and passing through a discharge resistance of 0.56 ohms so that the voltage which would have been thrown across the exciter momentarily would have been 308 volts. This might have been enough to demagnetize an exciter set at 275 volts, although it is thought that the time required to weaken and reverse the exciter magnetism would be greater than the duration of the induced generator field current at its maximum negative value. Another factor preventing demagnetization of the exciter is that the field current of the high pressure unit would have to be negligible or also reversed at the same time, since the net current in the common exciter is the sum of the instantaneous field currents in the high and low pressure units.

In each case when the field switch was closed, the field current instantly started to build up in the right direction, the armature currents returned to their normal values in about 5 seconds, the station voltage recovered to almost normal in the same length of time, and in about 20 seconds the station voltage had completely recovered. In each case the machine recovered synchronous speed in less than 2 seconds.

As a result of these tests and of a number of questionnaires sent to operating companies and manufacturers, fairly definite conclusions may be drawn. It is felt that when for any cause the field switch of a loaded alternator is opened unexpectedly, the usual practise of taking the unit off the system, re-exciting and resynchronizing it, is unnecessary and that considerable time in restoring normal operations without severe disturbance to the system is obtained by closing the field switch as soon as possible. The generator need not be removed from the bus at any time except in rather remote cases. It is recognized that different types of generators behave differently when the excitation is cut off, and that the older units having low resistance field windings and operating with 125-volt excitation are more erratic than later machines employing 250-volt excitation. It may be safely stated, however, that if the unit is carrying less than three-quarters load, there is no danger in reclosing the field switch. If the unit is carrying more than three-quarters load it will be prudent to lower the governor before reclosing the field switch. Also, if the bus voltage has dropped to 60 per cent of normal it is considered advisable to cut off the generator so as not to increase the tendency of other generators dropping out of step. However, such a reduction in voltage due to an open field is unlikely on large systems.

Owing to its reactance, it is impossible for the rotor field to increase to full strength immediately; it also follows that due to a weaker magnetic coupling it is impossible for the rotor to change speed instantly, and there can be no shock such as occurs when a machine is paralleled out of phase. To insure proper polarity when closing the field switch, the exciter, if self-excited, should always be operated above the knee of its saturation curve. The belief that while the switch is open excessive current which would prove injurious might be induced in the field winding was not borne out by the observed values of current.

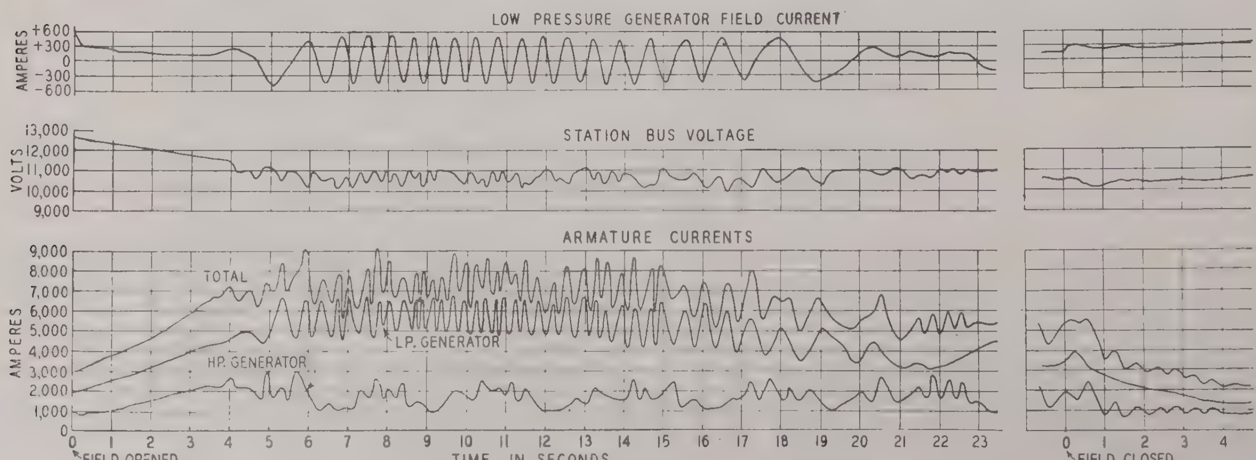

Fig. 2. Effect of opening and later reclosing the field switch of unit No. 2 at Crawford Ave. station. The machine was carrying 50,000 kw. at 80 per cent power factor when field was opened

Hinged Wooden Arms Used on Osage-Rivermines Line

Extra insulation was obtained on this important link of the Union Electric Light and Power Company transmission system by the use of wood crossarms. By hinging the arms to the steel tower structures, arm and tower stresses were reduced materially; consequently tower weights and line costs were lowered accordingly. Details of these and other major features of this unusual line are given in this article.

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HINGED WOOD CROSSARMS have been adopted for the 119.5-mile power transmission line which connects from the Osage hydroelectric development to the Rivermines substation of the Union Electric Light and Power Company (Mo.). Wood arms were selected because service requirements demanded better performance than that usually obtained with double circuit lines supported by all steel structures. These arms were hinged to the steel structures because of cost considerations: with such construction the forces applied to both arms and towers when conductor wires break are much lower than with rigid arm towers; consequently the cost of such towers is from 15 to 20 per cent lower than for rigid arm towers. Tests showed that with these arms and 11 insulator units, the line insulation is equivalent to that obtained with from 17 to 23 units on steel arms. Design of the arm involved the development of a suitable clamp for the tension member, details of which are given later.

The Osage hydroelectric development[1,2] (for numbered references see bibliography) is situated near the geographic center of the State of Missouri and about 140 miles west of the load center of the Union Electric Light and Power Company. Initial development includes six 33,500-hp. generating units. Two 132-kv. transmission lines were built to deliver the plant output to the existing transmission system which in a general way follows the Mississippi River from Keokuk, Iowa, on the north to the lead mining district near Rivermines, Missouri, on the south. One of the new lines is a single-circuit wood-frame line 135.5 miles long reaching from Osage to the Page Avenue substation in the outskirts of St. Louis; the other is the steel tower line with hinged wood crossarms, which is the subject of this article.

Important data of the Osage-Rivermines line are summarized in Table I. Each of the two circuits is designed to handle the output of two hydroelectric generators each rated 23,888 kva. at 0.9 power factor, and 60 deg. cent. (27,500 kva. at unity power factor, and 80 deg. cent.) through a single bank of transformers. Later, the power station may be equipped with a main bus, whereupon either circuit may be called upon to deliver the full air-blast bank rating of 60,000 kva.

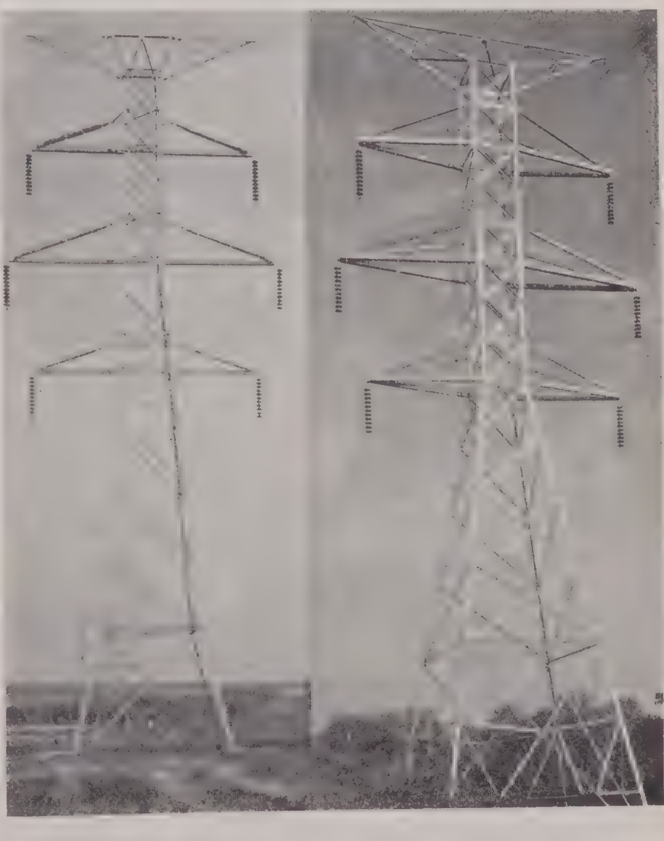


Fig. 1. Typical tower with hinged wood arms (left) and (right) tower with rigid wood arms as used at angles in the line and at certain long spans

Written especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

Energy transmitted annually will vary between 50 and 250 million kw-hr. per circuit.

To make the best use of the hydroelectric development, it will be operated as a peak cut-off plant replacing equivalent steam capacity in St. Louis. Such a procedure can be justified only on the basis of equal reliability. At a distance of 120 miles in a country with Missouri's record for sleet and lightning, this is an exacting requirement but was accepted as the basic specification for the Osage-Rivermines line.

A double-circuit steel tower line had been considered as being most suitable from a cost standpoint; yet it was felt that the service required fewer outages, particularly those involving both circuits, than the records of this type of construction would indicate as probable for a 120-mile line. More insulation seemed to be the principal need and it was suggested that some of the advantages of wood pole line construction might be realized by using wood crossarms.[3,4,5,6]

A preliminary study of the application of wood insulation to the crossarm assembly showed that it would involve a marked increase in cost as compared with steel unless some compensating measures were adopted. Aside from an arbitrary reduction in the factor of safety, which was considered with some misgivings, the only course available was to reduce the forces applied to the arms and tower when conductor wires break. The problem of reducing the forces from broken wires has received quite a bit of attention from transmission engineers and has resulted in the development of a number of slip clamps as well as in the hinged crossarm. (The metal hinged arm is not new.[7] Its operation was demonstrated publicly in this country in 1927 and the Public Service Company of Northern Illinois has 3 miles of line with hinged steel arms built in 1928.)

For the foregoing reasons, therefore, and because of its adaptability to the wood insulation idea, hinged arm construction finally was adopted. The arms are hinged at the tower end on an axis inclined away from the tower at the top by an angle of 20 deg. This inclination of the axis causes the swinging movement to be restrained by the weight of the arm and by any vertical load it may be carrying, so that normally the arm acts in the same way as though it were rigid. If a wire should break, the arm swings away from the broken span reducing both torsional and overturning moments.

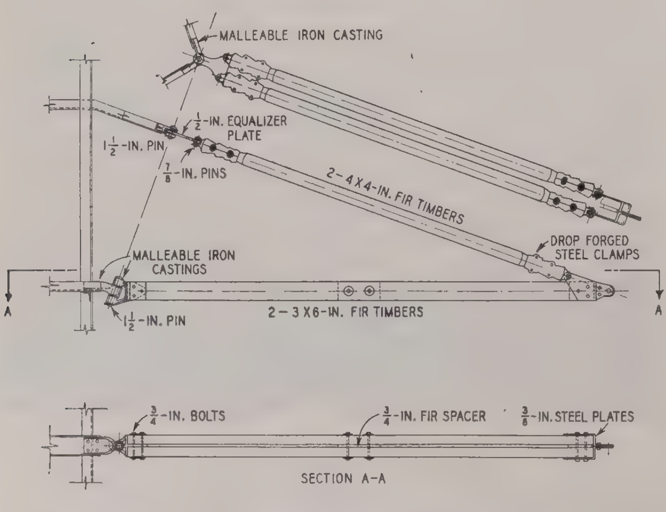


Fig. 2. Details of hinged wood arm

Design of Hinged Wood Arms

Construction of the arm is quite simple, consisting as it does of a pair of tension members and a compression member pinned together at the outer end. (See Fig. 2.) Tension members are in duplicate while the compression member is built up from two similar timbers bolted together; this is to minimize the effect of any shattering from lightning. With either tension member or either half of the compression element put out of commission, the assembly still is strong enough to carry any normal loads likely to occur.

Untreated Douglas fir was chosen as the material for the arms because it offered certain advantages in durability, strength, availability, economy, and ease of working. Some of the more important mechanical properties of the grade of wood selected are approximately as follows:

Tensile strength	7,000 lb. per sq. in.
Shear strength parallel to grain	900 lb. per sq. in.
Compressive strength perpendicular to grain	500 lb. per sq. in.
Compressive strength parallel to grain	3,500 lb. per sq. in.

No extraordinary difficulties were encountered in the design of the compression member. The tension member, however, offered a rather serious problem because of

Table I—Pertinent Features of Osage-Rivermines Line

Length. 119.5 miles (631,014 ft.) all on steel towers.

Circuits. 2—132-kv., 3-phase, 60-cycle.

Conductors. 6—250,000-cir. mil, 19-strand, copper.

Ground wires. 2—7/16-in., 7-strand, Siemens-Martin steel, galvanized.

Standard tower height. To peak 91 ft.; to bottom conductor 42 ft.-4 in.

Standard tower extensions. Single or multiple leg extensions, 4 ft. and 8 ft. Body extensions, 16 ft. Footing extensions, 2 ft.

Standard tower wire spacings. Horizontal Between Circuits: ground wires, 29 ft.; conductors, top 29 ft., middle 35 ft., bottom, 29 ft. Vertical: between conductors 14 ft.; between ground wires and top conductors 20 ft.-8 in.

Length of span. Average 827 ft., normal 700 ft., maximum 2,208 ft.

Standard tower loading. Equivalent span for vertical loading, 1,500 ft. Equivalent span for transverse loading 1,100 ft. Wire loads $\frac{1}{2}$ in. radial ice and wind pressure of 8 lb. per sq. in.; any two wires broken; factor of safety against failure 1.5.

Wire tensions (normal span). Conductor: 2,450 lb. at no ice, no wind, 60 deg. fahr.; 5,500 lb. at $\frac{1}{2}$ in. ice, 8 lb. per sq. in. wind pressure, 0 deg. fahr. Ground Wire: 1,300 lb. at no ice, no wind, 60 deg. fahr.; 4,250 lb. at $\frac{1}{2}$ in. ice, 8 lb. per sq. in. wind pressure, 0 deg. fahr.

Standard tower weight. Tower proper, 7,600 lb.; hinged arms 2,100 lb. (timbers, 1,000 and metal parts, 1,100); footings 1,200 lb.; total, 10,900 lb.

Standard conductor arms. Hinged on axis tilted 20 deg. from vertical. Duplicate tension members, 4x4-in. fir with forged steel clamps. Compression member, 2—3x6-in. fir timbers, blocked and bolted together. Wood insulation varies from 6.3 to 10.3 ft.

Insulation. On wood arms, 11-unit suspension strings, 13-unit strain strings. On steel arms, 16-unit strings. No arcing horns on initial installation.

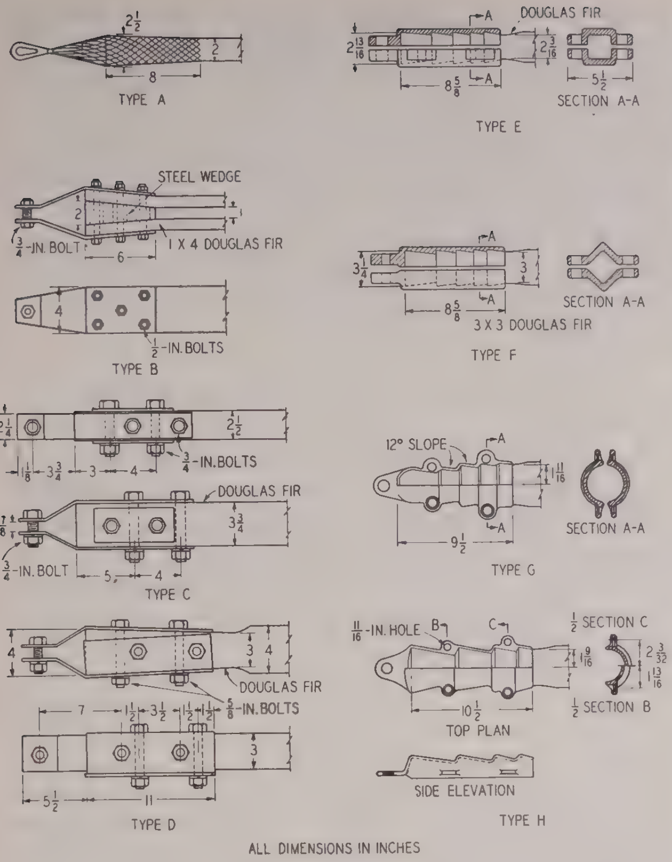


Fig. 3. General types of wood strain insulator fittings tested; type H finally was selected

See Figs. 5 and 6 for general theory and design of wedge type clamps applying to all of the above fittings

Fig. 4. Tension members of hinged wood arms showing method of applying clamps

the difficulty of making an attachment to a wood member so as to develop any great portion of the load which the wood is capable of sustaining in tension. This is because wood is comparatively weak in shear parallel to the grain and in compression perpendicular to the grain.

With these facts in mind, an extensive series of tests was conducted to develop a fitting suitable for the tension member. Some of the more general types of fittings tested are shown in Fig. 3. Type *H* fitting finally was adopted, it having been found to possess the following advantages:

1. Tendency of the wood to decay should be comparatively small as the clamp encloses almost the entire member, at the same time providing ventilation, and as there are no bolts through the wood.

2. Probability of the wood splitting due either to lightning strokes or to seasoning is eliminated largely by the clamping action of the fitting.

3. The metal is in close contact with the wood at all times; hence, the device should be free from leakage current troubles.

4. Strength of the attachment is not affected materially by a small amount of shrinkage in the wood because the taper permits a corresponding slippage which in turn readjusts the clamp. Experience has indicated, however, that if the wood is put up green and allowed to season in place, the bolts should be tightened after the wood has taken its initial shrinkage.

5. Drop-forged hot galvanized steel clamps of this type with copper bearing surfaces provide the required strength and length of life, with a high degree of reliability.

Two of the fittings are clamped onto each end of a 4x4-in. timber to make up the complete tension member (the ends of the timber of course being turned down to the proper shape). (Fig. 4.) In the wedge-like operation of this fitting the tensile load is translated into compression and shear stresses, the ratio between the two being controlled by the angles of the sloping surfaces and their coefficients of friction (see Figs. 5 and 6). By making the steps near the end of the stick successively smaller in diameter, each step tends to work on a different set of fibers with the result that the load is well distributed throughout the timber.

Ultimate breaking strength of the member with this type of fitting varies from about 35,000 lb. for a clamp having galvanized wedge surfaces, to about 50,000 lb. for a clamp having rough wedge surfaces. This difference is due to the fact that, for a given pull, the corresponding compression load on the wood varies inversely as the tangent of the sum of the friction angle and the angle of inclination of the wedge surfaces (see Figs. 5 and 6).

The compression member consists of two 3x6-in. timbers bolted together with ½-in spacers at the midpoint or third points, depending upon the length of the arm. (Figs. 2 and 7.) The end fittings were designed to bring as much of the compression load as possible directly upon the ends of the timbers rather than on the bolts the primary function of which is to hold the assembly together rather than transmit load. The fitting at the outer end is made up from forged steel plates which in addition to applying the load to the compression element, provide places of attachment for the tension members and the suspension insulators. At the tower end the compression timbers are seated in a malleable iron casting which forms the rotating part of the hinge.

Compression and tension elements were assembled individually in the factory; these were pinned together in the field, then hoisted up the tower as a complete arm and attached by inserting the two hinge pins. This operation proved to be quite simple as did the stringing of conductors, the latter operation being carried out in quite the same manner as on rigid arm construction.

During the rather extensive tests carried out in connection with the design of these arms, certain important details appeared as being fundamental to the success of an undertaking such as this. These are listed in the hope that they may prove helpful in any similar project in the future; they are briefly:

1. Rigid purchase specifications should be set up and repeated inspection made of each piece of timber during process of manufacture.

2. Proper attention must be given to the method of drying, whether done in kilns under special specifications or by other means.

3. If any form of treatment be used, care must be taken that the treatment does not lower the electrical resistance of the wood unnecessarily nor weaken it mechanically due to the high temperature sometimes employed.

4. Clamps and fittings attached to the timber must contain adequate provision for shrinkage across the grain and should be fitted accurately so as to distribute the stresses properly.

5. Thin sections in timbers exposed to the weather should not be used because of the unavoidable checking which becomes more serious with such sections, and the greater rate of depreciation due to the increase in exposed area.

6. Careful design can reduce the difficulties due to splitting by lightning when attention is given to the location of or possible reduction in the number of bolts through the timber. At points where electric current is likely to leave the metal and pass into the wood, the stress can be distributed somewhat by slightly flaring the metal away from the wood, rather than concentrating such stress upon a single line at sharp edges.

7. Normal continuous working stresses should be low. In designs providing for heavy ice loading this will be obtained automatically when ample strength is provided for the ice load; also in designs which provide duplication of parts to guard against the loss of such members due to lightning, similar low stresses will be obtained for normal loading.

In a relative evaluation of the above items, the first and the last probably are of greatest importance.

In this day of almost universal treatment of timbers in permanent outdoor structures, it may be surprising to some that the wood arms used in this line were not treated in any way. Treatment with creosote oil admittedly lengthens the serviceable life of wood and probably cuts down the amount of checking to a certain extent; but it had two important disadvantages in this application: it cuts down the lightning flashover voltage, definitely if slightly; and due to the lubricating qualities of the oil, it upsets the balance of design in the friction clamp on the tension member. Furthermore, as stated previously, unless extreme care is taken, there is a possibility of reducing the mechanical strength of some types of wood by the temperatures attained in treating.

It having been decided for these reasons to use untreated wood, the choice quite naturally fell to Douglas fir as mentioned previously, the highest commercial grade of which (dense superstructural) was selected. As seasoned timber of this grade is not available in any great quantity, for this job all of it was specially cut from green logs. This meant that most of the shrinkage took place after the arms were on the towers. This was anticipated and a general tightening of all bolts accordingly was scheduled for the end of the first summer season. Checking was aggravated to some extent by exposure to the intense summer heat without a preliminary seasoning.

The principal risk assumed by the substitution of wood for steel in a crossarm is the chance of shattering from lightning. The exterior of the tension members used in the electrical tests (described later) was quite badly splintered by the repeated flashovers; it is probable that the damage from real lightning would have been much worse. An attempt has been made to minimize these effects, however, by proper design of the metal fittings and provision is also made for attaching arcing horns if they should prove advisable; but the main reliance is placed in the overhead ground wires, in the duplication of the tension members, and in the two part construction of the compression element of the arm.

Insulation Tests on the Wood Arms

As a check on the increase in insulation due to the wood arms, part of a tower was set up in the Trafford high voltage laboratory and the minimum surge to flash over a string of eleven 5.75x10-in. insulator units on each arm was determined. The measurements with the equivalent insulation in number of similar insulator units on steel arms were:

Top arm	1,350 kv. (crest)	17 units
Middle arm	1,720 kv. (crest)	22-23 units
Bottom arm	1,550 kv. (crest)	20 units

Surges used for the tests rose to maximum value in 1.5 microsec. and fell to half voltage in 60 microsec. Flashovers for minimum surges had a time lag of about 40 microsec.

The arc from the top conductor jumped to the wood tension member of the middle arm, and followed this member to the tower; arcs from the middle and bottom conductors flashed up the insulator strings and to the tower, sometimes by way of the tension members and

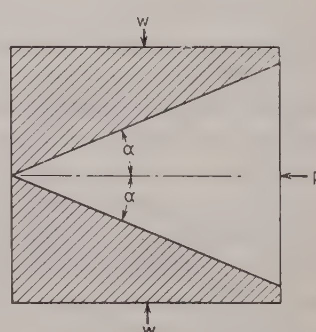


Fig. 5. Friction clamp theory for all fittings shown in Fig. 3

w = Force exerted by resisting body
α = Angle of inclination of the sides of the wedge
ϕ = Angle of friction
p = Force required to push the wedge

$$p = 2\,w \tan(\alpha + \phi) \quad (1)$$

Similarly, the force required to withdraw the wedge is given by:

$$-p = 2\,w \tan(\alpha - \phi) \quad (2)$$

From eq. 1 may be seen that for a given value of p, load w decreases when $\tan(\alpha + \phi)$ increases. In cases where it is desirable to keep w as small as possible and it is not feasible to increase angle α, the desired result may be obtained by employing an abrasive on the bearing surface of the wedge, thus increasing angle ϕ.

Wedge will not keep itself in position if α is greater than ϕ. This fact is worthy of consideration where the wedge is subjected to varying loads and is made of a material whose maximum allowable stress depends greatly upon the duration of the stress. In applications of this nature, α should be greater than ϕ in order that the wedge be only lightly stressed except during times of heavy loading.

sometimes by way of the compression members. Apparently enough variation existed in the resistance of the timbers to offset occasionally their difference in length.

To check the efficiency of the configuration from an insulation standpoint, measurements were made with varying insulator string lengths, crossarm lengths, and with and without adjacent crossarms. Principal criticism which developed from these experiments was to the effect that quite an appreciable gain in insulation for the top conductor could have been realized if the space between the top and middle arms had been increased by a foot or more.

Insulation of the line with eleven insulator units on wood crossarms is considerably higher than that of the substation equipment at the terminals. Therefore to assist the lightning arresters in protecting the substation apparatus from the hazard of lightning surges coming in from the line, the terminal stations are equipped with fused gaps. Owing to the difference in the equipment at the two ends of the line, the power station gaps are set at 40 in. and the receiving station gaps at 37 in.

Effect of Wood Arm Construction on Tower Design

Standard suspension towers with hinged wood arms do not appear greatly different from conventional towers (see Fig. 1) although the 20-ft. base and 4-ft. cage section used in this line are somewhat smaller than would be expected for towers 91-ft. in height. Ground wire supports are unusually prominent because of the location of the two ground wires, one being placed directly over the top conductor of each circuit with a vertical separation of 21 ft. With this arrangement, the ground wires should be well situated to intercept direct lightning strokes at midspan and divert them to the tower without side flashes to the conductor.[8] The increased moments due to this ground wire arrangement made it advisable to carry the batter of the legs up to the middle arm.

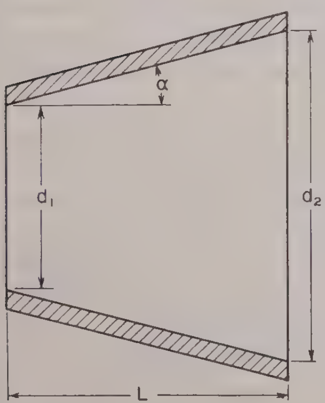


Fig. 6. Friction clamp design for all fittings of Fig. 3

α = Angle of inclination of wedge
ϕ_1 = Friction angle, wood on friction surface of clamp
ϕ_2 = Friction angle, wood on wood
S_t = Ultimate unit tensile strength of wood
S_c = Maximum unit compressive strength of wood, perpendicular to wedge surface
S_s = Maximum unit shear strength of wood parallel to the grain

For a balanced design

p = Tensile strength = compressive strength = shear strength, or
p = (Cross section at front end of clamp) (S_t)
= (S_c) (Cos α) (surface area of wedges) tan $(\alpha + \phi_1)$
= Shear area of base of wedge S_s + (Compressive load perpendicular to shear plane) tan ϕ_2

Practical considerations as to the size of the wood member to be employed might make a balanced design undesirable

A comparison between the tower design used in hinged arm construction and that which would have been required for a rigid arm line may be of some interest. It is quite apparent that towers for use with hinged arms involved the setting up of load assumptions different in some respects from those used in conventional rigid arm design. To show what these differences were and how they affected the tower design, a comparison has been developed between the hinged arm tower actually used on the Osage-Rivermines line and a tower with rigid wood arms otherwise structurally and electrically equivalent. This comparison is shown in Table II. Load assumptions used in this comparison represent unit stresses in the structures up to the elastic limit of the material beyond which it is assumed that tower failure would occur.

Vertical and lateral loads are the same for both types of construction, but in the case of broken wires the movement of the hinged arms will change the point of application of some of the loads. This introduces an unbalance in these loads which is not encountered in rigid arm design. However, the principal difference in loading rests in the magnitude and location of the longitudinal forces resulting from broken wires.

In rigid arm towers the longitudinal load generally adopted as a design basis is of the type indicated in Table II. For hinged arms the loads had to be based upon existing knowledge of hinged arm operation which was not very extensive. Lack of experience in this respect is reflected in the three more or less overlapping load assumptions (see Table II). With the accumulation of test data and operating experience, however, it is probable that a single longitudinal load assumption will be developed as in the case of rigid arm towers.

Effect of the hinged arm when wires break is to cause (1) a shift in the application of the longitudinal load to a point nearer the center of the tower, and (2) a reduction in the magnitude of this load to one-half its original value (except for the effect of impact at the end of the arm's swing which was assumed to build up to the original tension for an instant only). In case 3, where the impact forces of a breaking wire are superposed upon the forces resulting from a previously broken wire, the factor of safety was reduced as the result of a discussion as to whether or not case 3 was justified at all. These combined loadings were not applied lower than the first panel of the tower below the bottom crossarm because it was considered that the impact stresses would not extend beyond this point, but would be absorbed in the bolted connections above. Case 3 was found to be controlling in that part of the tower to which it was applied.

Weight distribution for the tower actually adopted for hinged arm service on this line is shown in Table I. Total weight of the tower (10,900 lb.) is approximately

2,000 lb. less than the estimated weight of an equivalent tower with rigid wood arms. As a result the cost of the hinged arm tower is estimated to be from 15 to 20 per cent less than for the rigid arm tower with which it has been compared. However, at certain locations in the line, namely, at angles and for certain long spans, hinged arms could not be used; for these cases rigid arms were required. In order that the insulation level might be maintained at these points, rigid wood arm assemblies were devised, the tension and compression elements being quite similar to those of the hinged assemblies. (See Figs. 1 and 8.)

Other Factors of Tower Design

One disadvantage of a double-circuit line in a "lightning" country is that construction economy tends to force the use of higher towers with consequent increased lightning exposure. This was particularly true in the case of the Osage-Rivermines line where the sharply rolling terrain continually offered opportunities for eliminating towers by the liberal use of tower extensions. Even with the exercise of some restraint in this respect, extensions varying in height from 4 to 16 ft. were justified for 40 per cent of the towers; this was on the basis that the saving in construction cost could not be offset by an intangible improvement in operation which might result from using more towers and shorter spans, and which in view of the high insulation of the line would be expected to be quite small anyway. As a concession to the electrical phase of this problem, however, the use of 16-ft. extensions on exposed ridges was limited to those locations where their application would not raise the conductors higher than at either of the adjacent towers.

Table II—Loading Comparison Between Rigid Arm and Hinged Arm Towers

RIGID ARM DESIGN

Vertical loads. Weight of insulators and wires with ½ in. radial ice, for 1,500-ft. spans, multiplied by 1.5; dead load of tower, multiplied by 1.5.

Lateral loads. Wind load of 8 lb. per sq. ft. acting on wires with ½ in. radial ice, for 1,100-ft. spans, multiplied by 1.5; wind load of 15 lb. per sq. ft. on 1.5 times the area of material in one face of tower, multiplied by 1.5.

Longitudinal loads. Unbalanced load of any two broken wires at full load of 5,630 lb. for conductors and 4,400 lb. for ground wires, multiplied by 1.5.

HINGED ARM DESIGN

Vertical and lateral loads. Same as for rigid arm design.

Longitudinal loads. Case 1. Unbalanced load of any one wire broken at full load but reduced to half tension by the arm swinging 90 deg. into the direction of the line; this loading combined with an impact load of equal amount (5,630 for conductors, 4,400 lb. for ground wires) multiplied by 1.5.

Case 2. Unbalanced load of any two wires broken at full load but reduced to half tension by the arm swinging 90 deg. into the line (2,815 lb. for conductors and 2,200 lb. for ground wires) multiplied by 1.5.

Case 3. Unbalanced load of any one wire broken at full load but reduced to half tension by the arm swinging 90 deg. into the line (2,815 lb. for a conductor or 2,200 lb. for a ground wire) multiplied by 1.5; this load combined with the unbalanced load of any one wire broken at full load but reduced to half tension by the arm swinging 90 deg. into the direction of the line, and an impact load of equal amount, (5,630 lb. for a conductor *or* 4,400 lb. for a ground wire) multiplied by 1.25. The effect of these loads should be considered only down to first panel point below bottom arms.

Fig. 7. Compression members of hinged wood arms showing method of applying clamps

Standard tower footing consisted of the familiar pyramidal framework resting on a square grillage. The only interesting departure from usual practise was suggested by the unevenness of the ground at the tower site. Sidehill leg extensions of 4 ft. or more had been provided for about 12 per cent of the towers, but many instances were found where a single leg extension of 2 ft. would be convenient. This need was met by designing a footing which projects 2 ft. out of the ground but which otherwise is similar to the standard anchor. The increased weight for one footing was only about 60 lb. and its advantages were many: it saved laborious cut and fill in material that was largely rock, and it permitted the establishing of higher grades with consequent gain in span lengths. Interchangeability of the two types of footings permitted the more general use of standard towers without the confusing inconveniences of substituting special leg and bracing material. More than half the towers in the line have one or more of these high footings.

Tower Ground Resistance

In view of the close relation between tower ground impedance and line performance under lightning conditions, the ground resistance of every tower was measured and recorded as an aid to analyzing any subsequent lightning outages. With ground wires detached, measurements were made by means of a direct reading megger ground resistance tester with a three-range scale (0 to 3 ohms, 0 to 30 ohms, and 0 to 300 ohms). Four readings were taken at each tower and the average taken as the tower ground resistance; each reading was taken between the tower base and two ¾-in. tool steel auxiliary ground rods driven into the earth to a depth of 3 ft. Positions of the auxiliary grounds were determined by tests. (See Fig. 9.) At many of the towers it was necessary to probe over a considerable area in order to find a place where the rods could be driven down 3 ft.; however, the arrangement of Fig. 9 was followed as closely as possible.

Results of these tests are shown in Fig. 10 from which may be seen that the footing resistances varied from less than 1 ohm up to 56 ohms, the average for all towers being 6.9 ohms. The measurements were made in an extremely dry season and soon after the towers were erected so that the earth had not settled around the

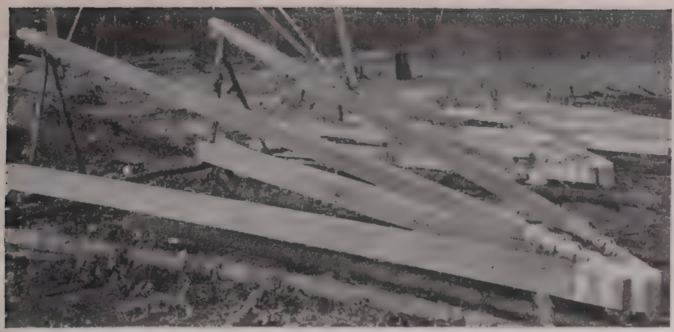


Fig. 8. Rigid wood arms as used at angles in the line and at certain long spans

footings. It is probable that after a few rains the earth will settle more compactly around the footings and that the ground resistances then will be somewhat lower.

Analysis of the curves in Fig. 10 show that 629 towers, or 83 per cent, of a total of 760 have ground resistances of 10 ohms or less. An examination of the 131 towers having resistances above 10 ohms brought out the fact that 46.1 per cent of these are set in sandstone, 37.5 per cent in limestone containing a large amount of chert, 14.1 per cent in limestone free from chert, and 2.3 per cent in sand and gravel. Approximately 5 per cent of the towers have resistances above 20 ohms, of which 70.5 per cent are set in sandstone, 20.6 per cent in limestone containing a large amount of chert, and 8.9 per cent in limestone free from chert.

No attempt is being made to lower any of the resistances at the present time because (1) average resistance of the line is low; (2) the high resistances are scattered along the line with not more than four consecutive towers having resistances above 10 ohms; and (3) the cost of lowering the high resistances would be excessive due to the fact that the footings on these towers are set in solid rock. Records of the locations of all flashovers will be kept and if it is found that the flashovers tend to concentrate on towers having high ground resistance, an attempt will be made to lower the resistance at these towers, or to provide some other form of protection.

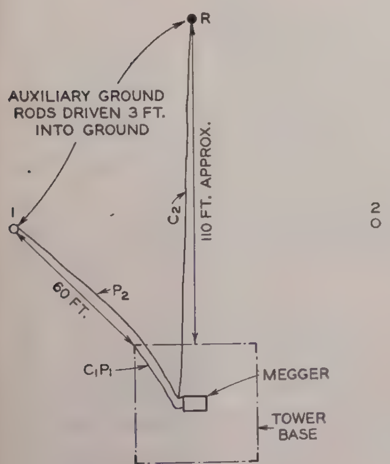
Some additional data on the ground return path was obtained from a test made primarily for measuring the inductive effects on neighboring communication circuits. One 250,000-cir. mil copper conductor was grounded 85 miles from the power station, and energized from one terminal of a generator with its neutral grounded through a 4-ohm resistor. Readings taken on this test were: generator potential to neutral, 3,720 volts; current, 31 amperes; power 48 kw. (frequency 60 cycles).

From these data the resistance of the ground return path was computed to be 26 ohms, and the 60-cycle reactance of the circuit, 109 ohms. Based upon this reactance, the distance from the conductor to the center of the return path was computed to be 720 ft. The low value for the depth of the return probably is due to the small current used in the test.

Line Laid Out from Aerial Survey

In conclusion, a word about the preliminary survey of the line location might not be amiss. This was unusual in that it was carried out entirely with the company's own aerial equipment and personnel. Planes and cameras are becoming available so generally that survey parties can be organized as readily for work in the air as on the ground.

The aerial method effected an enormous saving in time and expense in the location of this line. A series of contact prints from photographs taken at a constant height was assembled to give a 400-ft. scale map upon which the line was plotted. Sections of this assembled map were rephotographed for the use of the right-of-way department and an extra set of contact prints from the original films was used for stereoscopic study of the



R–Rivermines side of tower
C_1P_1–Current and potential lead of megger connected to tower
C_2–Auxiliary ground lead to megger current coil
P_2–Auxiliary ground lead to megger potential coil
1 and 2–Test positions for P_2 with C_2 located at R
Similar readings were taken on the Osage side of the tower

Fig. 9. Set-up for making tower ground resistance measurements

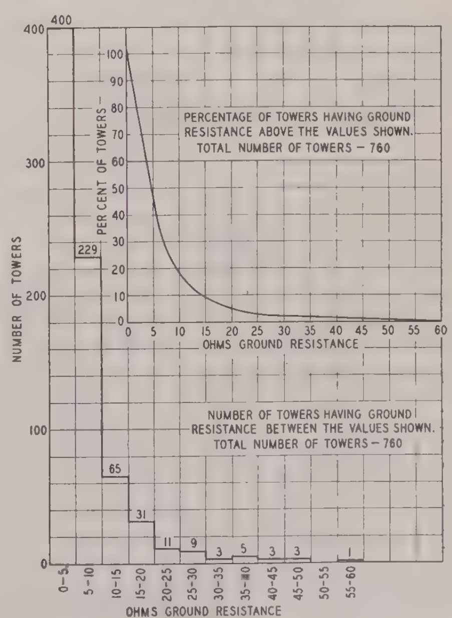


Fig. 10. Results of tower ground resistance tests

topography. Methods and equipment used have been described elsewhere.[9]

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Propagation Constant of a Transmission Line

Starting with the logarithmic variation of voltage and current along a transmission line, a derivation of the propagation constant is given in this article, depending only upon the application of Kirchoff's laws and simple hyperbolic trigonometry.

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WHEN a transmission line is infinite in length or is terminated in a load equal to its characteristic impedance, the voltage and current at various points along the line vary logarithmically as shown in Fig. 1, and are said to follow the laws of "normal attenuation." Considering, for example, the current wave, we may express the current at any point d miles from the generator end as

$$I = I_0 e^{-\gamma d}$$

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where I_0 is the current input to the line, $e = 2.7183$, and γ is a constant for the particular line at a given frequency and is known as the propagation constant. This constant is a complex number, since there is a change in phase as well as in magnitude of the current as it progresses from the generator end, and is usually expressed as

$$\gamma = \alpha + j\beta$$

α being known as the attenuation constant and β as the phase or wavelength constant. In the case of normal attenuation, therefore, the current at any point d miles from the generator is completely expressed by the relation

$$I = I_0 e^{-\gamma d} = I_0 e^{-\alpha d - j\beta d} = I_0 e^{-\alpha d} \underline{/-\beta d}$$

That is, the current is reduced in magnitude by the "attenuation factor" $e^{-\alpha d}$ and shifted in phase by βd radians.

The propagation constant of a transmission line usually is developed by means of differential equations, a method which does not recommend itself in an elementary discussion of the laws of normal attenuation. A derivation of this constant which depends only on the application of Kirchoff's laws and simple hyperbolic trigonometry is given below.

Every transmission line has four important linear constants: R, the series resistance per loop mile; L, the series inductance per loop mile; C, the linear capacitance per loop mile; and G, the shunt leakance per loop mile. Thus for a short section of line, a mile for example, there will be a series impedance of $Z_1 = R + j\omega L$ ohms, and a shunt impedance of

$$Z_2 = \frac{1}{G + j\omega C}$$

ohms. Let the diagram in Fig. 2 represent three unit lengths of 1 mile each. Calling the current in the first series element I_0, that in the second element I_1, and that

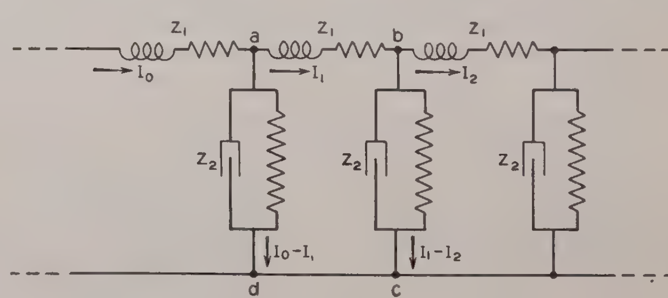

Fig. 2. Recurrent sections representing a transmission line

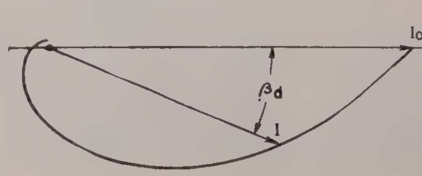

Fig. 1. Logar metic variatior current with r mal attenuati

in the third I_2, we have the current through the first shunt path $I_0 - I_1$, and that through the next shunt path $I_1 - I_2$. Writing Kirchoff's law for electromotive forces in mesh a-b-c-d, we have

$$Z_1 I_1 + Z_2 (I_1 - I_2) + Z_2 (I_1 - I_0) = 0 \quad (1)$$

Dividing through by $Z_2 I_1$, we have

$$\frac{Z_1}{Z_2} + 1 - \frac{I_2}{I_1} + 1 - \frac{I_0}{I_1} = 0 \quad (2)$$

which when rearranged becomes

$$\frac{I_2}{I_1} + \frac{I_0}{I_1} = \frac{Z_1}{Z_2} + 2 \quad (3)$$

The two terms on the left of this equation are ratios of the currents in adjacent sections of the line. Now if normal attenuation obtains, it is evident that this current ratio will be the same for any two adjacent sections, and if we call this ratio e^{γ}, the above equation takes the form

$$e^{\gamma} + e^{-\gamma} - 2 = \frac{Z_1}{Z_2} \quad (4)$$

Extracting the square root of both sides and dividing by 2,

$$\frac{e^{\gamma/2} - e^{-\gamma/2}}{2} = \frac{\sqrt{Z_1/Z_2}}{2} \quad (5)$$

Now the left side of this equation is recognized as the hyperbolic sine of $\gamma/2$, which for small angles is approximately equal to $\gamma/2$; so that the relation in eq. 5 may be written

$$\gamma = \sqrt{(R + j\omega L)(G + j\omega C)} \quad (6)$$

This is the customary expression for the propagation constant of a transmission line.

Transportation and a Nation's Diet

Scientific developments have improved natural foods and made possible their wide distribution. This is the eighth article in The Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"

By
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President, Burlington (Ry.) Lines

AMONG the many changes which have taken place in the living conditions of the average American during the past two decades, none is more striking than the change in diet. Ordinarily railway transportation is not thought of as affecting so vital a matter in the life of a people as an essential change in the kind of food they eat. Nevertheless, it is true that improved transportation of perishable products has brought about, or at least contributed greatly to, this change.

It is only in recent years that better refrigeration and expedited movement of fresh fruits and vegetables have brought to every city and village throughout the entire country every day in the year the products from those sections of the United States which specialize in horticultural delicacies. Advantages of a balanced diet containing fresh foods have been brought to the attention of the public by research and medical science, and the ability to grow these special products to greatest perfection has been developed simultaneously with the improvement in transportation which made practicable their distribution over such wide areas. In this way science in health, in horticulture, and in railway transportation, has coordinated to contribute towards happiness and longer life for many millions of people.

Perhaps the most remarkable example of how these changes affected a well-known product is the glorification of the lowly lettuce, which always has been a plant in the household garden. Some few years ago the fact was featured that certain vitamins which it contains are particularly desirable. Along with this came the development of head lettuce, which largely has taken the place of the old-fashioned leaf lettuce. The result has been that the shipment of lettuce over long distances has grown in the United States from 12,000 cars in 1920 to 55,000 cars in 1930.

Head lettuce is grown perhaps to greatest perfection along the Pacific Coast and in some of the western mountain valleys. A few years ago this would have prohibited its general use in the eastern states because of the perishable character of so delicate a plant. What has happened in this instance is typical of many others. Lettuce is not a new plant, but modern science and engineering have contributed to create a great consumptive demand which, in turn, has resulted in an attractiveness of the product as well as a distribution bringing about the growth of a great and extensive enterprise featuring an old-fashioned vegetable.

Editor's Note: Pursuant to the invitation of The Engineering Foundation, the editors will be happy to receive comments, suggestions, criticisms, or discussions pertaining to this or the other articles published in this series.

Abstracts

Of Papers Presented at the Winter Convention

INTERPRETIVE abstracts of the majority of papers presented at the A.I.E.E. winter convention (January 25-29, 1932) or articles based upon them, were published in the January issue of ELECTRICAL ENGINEERING. Interpretive abstracts of all remaining papers are presented herewith. Members vitally interested and wishing to obtain immediately pamphlet copies of any available papers are requested to use the order form appearing on p. 148 of this issue. In response to popular demand and within its space limitations ELECTRICAL ENGINEERING subsequently may publish certain of these papers, or technical articles based upon them.

Aging and Elastic Hysteresis in Instrument Springs

By
R. W. Carson[1]
P. MacGahan[1]

ACCURACY of electrical measuring instruments depends as much on the quality of the control springs as on the design of the torque producing elements. However, judging from the work published on the subject, the design of high quality control springs has not received its proper share of attention.

Unstable effects found in the use of spiral instrument springs arise from a temperature change in the elastic modulus of the spring material, from secular change or aging in service, and from elastic hysteresis, all of which may under certain conditions introduce appreciable errors.

Secular change or aging in service was found to be caused by residual stresses in the spiral spring arising from the manufacturing process and was eliminated by a low temperature heat treatment. Elastic hysteresis was studied with the use of the grid glow micrometer. A study of the effect of composition and cold working, residual stresses and thermal treatment, temperature, intensity, and duration of loading on elastic hysteresis effects lead to an improved manufacturing process.

An Automatic Oscillograph

By
C. M. Hathaway[6]
R. C. Buell[6]

AS A RESULT of the new era of extensive interconnection of large power systems and of the high speed operation of switches and circuit breakers, problems have arisen that only an oscillograph can solve; further an oscillograph for such applications must have characteristics that are not found in those designed for more general usage.

An oscillograph for such applications of course must be fully automatic because short circuits and faults are usually unanticipated, it should be able to take a considerable number of records successively whether the faults follow each other in rapid succession or are days or weeks apart, and it should start recording within one-half cycle of the beginning of the initiating disturbance. The automatic oscillograph described in this paper has been designed to meet these requirements, being intended primarily for the recording of chance and unanticipated disturbances in power systems and in electrical machinery. (**A.I.E.E. Paper No. 32-47**)

Surge-Proof Transformers

By
H. V. Putman[25]

TWO FEATURES in connection with recently improved transformer construction are of special interest: First, without the use of shields to neutralize ground capacity, it has been possible to build shell type transformers in which the distribution of surge voltages is substantially uniform, and which are practically non-oscillating even for the longest surges; second, a major improvement in the impulse strength of the insulation has been made through the elimination of creepage surfaces from the entire insulation structure.

Ordinary methods of shielding, even though equalizing the voltage stress on the insulation between turns and coils, still permit high stress concentrations in the major insulation between windings and ground at the ends of the coil columns or groups. Furthermore, shielded transformers require most careful consideration in design, because of the introduction of large metal surfaces at line potentials in close proximity to the entire high voltage winding. The initial distribution in the new surge-proof transformers not only is substantially uniform within the winding, but the voltage stress is fairly uniformly distributed throughout the entire insulation structure. These results have been obtained simply by employing proper design proportions and coil arrangements, no shields being used. Further improvement in operation has been secured by many years of research on transformer insulation. (**A.I.E.E. Paper No. 32-29**)

Effect of Transient Voltages on Power Transformer Design—IV

By
K. K. Palueff[8]
J. H. Hagenguth[8]

THE IMPACT of a surge on the high voltage terminals of a transformer produces transient voltages not only within that winding, but also within the low voltage winding and at its terminals. The latter voltage, discussed in this paper, is impressed on the network and apparatus connected to the secondary wind-

1. Westinghouse Elec. & Mfg. Co., Newark, N. J.
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8. General Electric Company, Pittsfield, Mass.
17. Bell Telephone Laboratories, Inc., New York, N. Y.

ing. The possibility of the transmission of high transient voltages through transformers is indicated by occasional failures during lightning storms of rotating apparatus connected to lines through transformers.

The transient voltage on the secondary circuit may be considered as the result of superposition of four components; namely, electrostatic voltage, free oscillation in the high voltage winding, free oscillation in the low voltage winding, and electromagnetic induction. All four components depend to a different degree upon surge impedances and lengths of external circuits connected to the transformer. A study of these surge voltages enables definite conclusions to be drawn concerning the voltages produced on the secondary circuits, especially those caused by the electromagnetic component, which is of more general importance than the others. (**A.I.E.E. Paper No. 32-49**)

Standard Decrement Curves

By W. C. Hahn[22] C. F. Wagner[2]

THE DETERMINATION of decrement in power system short-circuit currents frequently is necessary for circuit breaker and relay application. For this purpose certain standard decrement curves originally appearing in 1918 and revised in 1923, have been in general use. New decrement curves now have been derived to supersede the former ones, the new curves having been made desirable by the considerable progress in analysis of transients in synchronous machines, and to the use of symmetrical components for calculating unbalanced faults.

The new decrement curves take into consideration the fact that the a-c. component is made up of two exponential terms, and that the transient time constant varies with system reactance. Because the new curves are based upon the method of symmetrical components, a single set is applicable to three-phase, line-to-line, and line-to-ground faults. Distinction is made between machines with and without damper windings.

In addition to presenting these curves the paper includes also the underlying assumptions upon which they are based, the method of their application, and their limitations. (**A.I.E.E. Paper No. 32-53**)

Calculation of Short Circuits on Power Systems

By C. F. Wagner[2] S. H. Wright[23]

CURVES presented in the companion paper "Standard Decrement Curves" are sufficiently accurate for most commercial work, particularly circuit breaker applications. Many special cases arise, however, for which these curves are not applicable. Of this character are relay applications on power systems involving several machines having different time constants and located unsymmetrically with respect to the fault. The individual branch currents in systems of this character may have widely different decrements and even may increase with time. Need, therefore, exists for a method of calculation which will take these individual variations into consideration. Such a method has been developed and has been termed the "internal voltage" method of calculation. It is particularly valuable in that it lends itself to the use of the calculating board and thus minimizes the labor involved.

In the present paper, part I is concerned with an extension of the standard decrement curves and part II with a discussion of the internal voltage method of calculation. Another important factor affecting short-circuit currents is the effect of the increase in exciter voltage during system faults. In part III is developed a semi-graphical method of determining this factor. (**A.I.E.E. Paper No. 32M4**)

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23. Buffalo Niagara and Eastern Power Corp., Buffalo, N. Y.

Decrement Curves for Specific Systems

By W. C. Hahn[22]

GENERAL curves showing the current decay during system short circuits are given in the companion paper "Standard Decrement Curves." Inasmuch as arrangements of systems and characteristics of synchronous machinery vary considerably, a single set of general curves based upon certain assumptions as to system layouts, time constants, etc., will be only approximate, and in some cases considerably in error. It is desirable therefore to have available more accurate methods for obtaining decrement factors. It is the purpose of the present paper to describe the methods by which are obtained these more accurate decrement factors especially adaptable to specific arrangements.

The curves in the companion paper are constructed upon the idea of only one necessary calculation: that required to obtain the initial subtransient current in the short circuit. This may be called a one-point method. It is possible, however, to use the same curves in a more accurate manner by making two calculations based, for example, upon the initial subtransient and transient currents. Use then is made of the general decrement curves having the same ratio of subtransient to transient current as the actual system. A different procedure based on a three-point method may also be used. (**A.I.E.E. Paper No. 32M5**)

Cobalt Magnet Steel

By P. H. Brace[2]

IN THE iron-cobalt series, an alloy, Fe_2Co, having the highest known saturation intensity of magnetization was discovered. This led to the development of new and remarkable permanent magnet steels based on that alloy. The better of these showed residual induction equal to, and coercive forces three to five times as great as, those of the better magnet steels previously available.

As a result, relatively short and light permanent magnets capable of maintaining high field intensities became possible. Advantage of this has been taken in the construction of portable oscillographs; compasses, ignition magnetos and generators for aircraft; indicating and watt-hour meters; magnetic survey apparatus; telephone receivers and traffic control equipment.

The basic alloy Fe_2Co alone is useless as a permanent magnet material. Its utility in this connection results from addition of less than eight per cent of alloying elements in fairly definite proportion, supplemented by appropriate heat treatment. From the magnetic standpoint the best composition contains the following approximate percentages: iron 54, cobalt 38, chromium 4, tungsten 2, carbon 0.95, manganese 0.5, and minor elements and impurities 0.55.

At the present price of two dollars per pound, such material cannot compete with the usual magnet steels on the basis of material cost per unit of magnetic performance and hence its use is economically justified only when savings of space or weight or its high coercive force can be capitalized. Compromise alloys of lower cost and less magnetic ability have become available.

Cobalt represents the chief item of cost, but world resources, notably in Africa, Canada and the United States appear such as to give hope for improvement as a larger and more stable market develops. The reported consumption of high-cobalt magnet steel is now of the order of 75,000 lbs. per year. Six manufacturers of alloy steel in the United States are in a position to supply cobalt magnet steel. **Pamphlet copies not available.**

High Capacity Rectifier Efficiency Improved by Sectionalizing

By A. L. Atherton[25]

THE IDEA of the sectional type mercury arc rectifier is based on the obvious, but heretofore apparently unrecognized, fact that the best inherent possibilities are realized only in the smaller sizes. Efficiency, reliability, economy, and flexibility are all far better in small units than in large.

Multiple installations of the conventional small capacity units which have been available in the past are impracticable. The new sectionalized rectifier although built in sections, is installed, controlled, protected, and used as a whole, and the desirable qualities of the small rectifier thus are made available for the larger capacities while the disadvantages of sectionalizing are so reduced as to become negligible. (**A.I.E.E. Paper No. 32-50**)

Time and Its Measurememt

By E. W. Brown[24]

A TIMEKEEPER, whether terrestrial or celestial, may be considered as consisting essentially of a fixed dial and a moving pointer. A complete observation may be regarded as a comparison of the angles described by the pointers of two timekeepers between two signals.

The measurement of time is considered in this paper from the standpoint of securing the greatest possible accuracy for use in scientific studies, and far more accurately than needed in everyday life. Standard timekeepers are discussed and definitions of error, rate, and other factors are given.

The fundamental standard for time measurement is the rotation of the earth upon its axis. However, various errors are present in this standard and difficulties are involved in its observation. The difficulties in obtaining an absolutely accurate standard are exemplified in the fact that even the observatories taking the most accurate measurements show differences among themselves. (**A.I.E.E. Paper No. 32-51**)

Modern Developments in Precision Clocks

By Alfred L. Loomis[30]
W. A. Marrison[17]

ULTRA-PRECISE practical timekeepers of today can be placed within two classes, depending upon whether the restoring force is gravity, as in pendulum clocks, or elasticity, as in quartz crystal oscillators. The second class is a development of the last decade and was made possible by the vacuum tube and associated electrical circuits. Intercomparisons between timekeepers of the two classes provide a most valuable means for the study of changes in gravity and related phenomena.

The three gravity clocks most often recognized as precision timekeepers are the Leroy, Riesler, and Shortt; one or more of these are to be found in most of the important time laboratories and astronomical observatories throughout the world. While the crystal clock assembly is more costly than that of a pendulum clock and requires more associated electrical equipment, it is believed that for many purposes it is decidedly superior because of its great versatility. (**A.I.E.E. Paper No. 32-52**)

Direct Printing Over Long Non-Loaded Cables

By M. H. Woodward[34]
A. F. Connery[34]

NOTWITHSTANDING the rapid progress that has been made in recent years in the application of automatic printers to landline operation, and the continued efforts to apply similar methods to the operation of long non-loaded submarine cables, the siphon recorder, which requires manual translation, still is used almost exclusively in the operation of such circuits. While the recently developed loaded type of submarine cable possesses characteristics which permit of its being operated with a modified form of landline multiplex printing system, the numerous attempts to develop and apply a satisfactory direct printing system to non-loaded cables have not met with complete success.

It is the purpose of this paper to outline briefly the various factors which enter into this problem and to describe a new type of cable printer which has been developed and placed in successful operation on cables between London and New York and also between New York and points in Central and South America and the West Indies. A method is described for the electrical conversion of the non-uniform length combinations of the cable Morse code into a modified five unit code and its application to printers on long non-loaded submarine telegraph cables.

Vector Theory of Circuits Involving Synchronous Machines

By I. H. Summers[37]

PREVIOUS publications have shown that calculations of the performance of a synchronous machine may be simplified by the use of two scalar impedance operators which apply separately to the component of armature current which magnetizes in the axis of the poles, and to the component which magnetizes in the axis of the interpolar space.

The present paper describes a method of combining these two scalar operators into a single vector operator which applies directly to the total current. With the new operator it becomes possible to write out the complete equations which apply to various numbers of interconnected machines, under various operating conditions, as readily as would be possible if each machine were replaced by a fixed source of voltage operating through a constant value of impedance. The effect is to simplify the labor greatly and thus to extend the scope of synchronous machine analysis, particularly in cases in which more than one machine is involved. It is believed that the theory developed will be of value to engineers who are working on problems such as stability, hunting, pulling into step, and other problems of this general character which involve detailed analysis of the operation of synchronous apparatus under transient conditions. An introduction to this article has been prepared by R. H. Park. (**A.I.E.E. Paper No. 32-48**)

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25. Westinghouse Elec. & Mfg. Co., Sharon, Pa.
30. Loomis Laboratory, Tuxedo Park, N. Y.
34. International Communications Laboratories, Inc., New York, N. Y.
37. Deceased. Formerly of the General Elec. Co., Schenectady, N. Y.

News

Of Institute and Related Activities

Great Lakes District to Meet at Milwaukee

COOPERATION of local educators, manufacturers' representatives, and public utility men has enabled a technical program covering a variety of interests to be arranged for the three-day meeting of the A.I.E.E. Great Lakes District, No. 5, which will be held at Milwaukee, Wis., March 14-16, 1932. Headquarters will be in The New Pfister Hotel. In addition to the technical program, Milwaukee and its environs with their well known industries should hold much of unusual interest for the visitor.

TECHNICAL SESSIONS

Three technical sessions will be held, one on each day of the meeting. The first session embraces papers in the fields of electrophysics, research, and communication. The second session will bring forth papers on the development of the Waukegan Station and its electrical design features; another paper will describe a 115,000-kw. turbo-alternator; two others will treat line wire insulation and factors affecting spark-over of insulators and bushings. The third session will be devoted to problems in connection with railway electrification and transmission. A student session also will be held and papers by the students within the District will be presented.

The many interesting inspection trips and entertainment features being arranged will be announced later.

HOTEL RESERVATIONS

Members should make their reservations by writing directly to the hotel preferred. Rates for the headquarters hotel, The New Pfister, as well as several other hotels are given in the accompanying table.

Tentative Technical Program

Monday, March 14

Session No. 1—*Presiding:* C. F. Harding

The Proximity Effect and Its Application to the Concentration of Heating Currents, Edward Bennett, University of Wisconsin.

*A General Method of Gaseous Tube Control, Carroll Stansbury, Cutler-Hammer, Inc.

*Electrical Instruments in the Gas Industry, E. X. Schmidt, Cutler-Hammer, Inc.

*Toll Switching Plan for Wisconsin, W. C. Lallier, Wisconsin Telephone Co.

*Police Teletypewriter System, R. E. Pierce, American Tel. and Tel. Co.

Tuesday, March 15

Session No. 2—*Presiding:* R. F. Schuchardt

*Development of the Waukegan Station of the Public Service Company of Northern Illinois, J. L. Hecht, Public Service Company of Northern Illinois.

*Electrical Design Features of Waukegan Station, E. C. Williams, Public Service Company of Northern Illinois.

*115,000-Kw. Turbo-Alternator, R. B. Williamson, Allis-Chalmers Mfg. Co.

*Weatherproof Insulation for Line Wires, C. F. Harding, L. L. Carter and J. W. Olsen, Purdue University.

*Factors Affecting Spark-Over of Insulators and Bushings, W. L. Lloyd, General Electric Co.

Wednesday, March 16

Session No. 3—*Presiding:* J. H. Foote

*A 60-Cycle Primary Transmission System, C. D. Brown and E. W. Hatz, The Milwaukee Elec. Ry. & Lt. Co.

*The Mercury Arc Rectifier Applied to A-C. Railway Electrification, O. K. Marti, Allis-Chalmers Mfg. Co.

*Mercury Arc Rectifier *Versus* Rotary Converter Automatic Railway Substations, O. M. Ward, The Milwaukee Elec. Ry. & Lt. Co.

*An Improved Type of Limiting Gap for Protecting Station Apparatus, A. O. Austin, Ohio Insulator Co.

Variation in Diameter and Spacing of Suspension Insulators, J. J. Torok and C. G. Archibald, Westinghouse Elec. & Mfg. Co.

Advance copies of papers for discussion will be sent to members as soon as available, upon written request to A.I.E.E. headquarters, 33 West 39th Street, New York, N. Y. Please indicate by title and name of author the paper or papers requested. At the meeting usually five minutes is allowed each discussor. When a member signifies desire to discuss papers on other subjects or groups he shall be permitted a five-minute period for each subject or group. Discussions are not reported; typewritten copies should be left with the presiding officer.

*These papers are under consideration for presentation at the Great Lakes District meeting, but up to the date of going to press have not been officially placed upon the program.

Hotels		Rooms Without Bath	Rooms With Bath	Suites
New Pfister, 200 rooms,	Single	$2.50 up	$3.50 up	$15.00
Jefferson St. and E. Wisconsin Ave	Double	$4.00 up	$5.00 up	up
Martin, 200 rooms,	Single	$1.50–$2.50	$2.50–$ 3.00	$ 4.00
201 East Wisconsin Ave	Double	$2.50–$3.25	$3.50–$ 6.00	up
Medford, 310 rooms,	Single	$1.75–$2.25	$2.50–$ 3.00	
Third and Michigan Sts	Double	$2.75–$3.00	$3.50–$ 5.50	
Schroeder, 850 rooms,	Single		$3.00–$ 7.00	$10.00
Fifth St. and Wisconsin Ave	Double		$5.00–$10.00	up
Wisconsin, 460 rooms,	Single	$1.50–$2.00	$2.50–$ 5.00	$12.00 to
182 Third St	Double	$3.00–$4.00	$5.00–$10.00	$20.00

Date of District No. 2 Meeting.—Announcement is made by K. A. Hawley, chairman of the Baltimore Section, that the general committee which is arranging the details for the Middle Eastern (No. 2) District meeting in Baltimore, Md., October, 1932, has decided that this convention will be held October 10-14 inclusive. The tentative program arranged includes registration and sessions on October 10 with sessions continued on the following days. A trip to the Safe Harbor hydroelectric plant on the Susquehanna River is planned for October 13.

Winter Convention Report.—At the time of going to press for this issue, the 1932 winter convention of the Institute was in progress at the Engineering Societies Building in New York City. A full report of this convention will be given in subsequent issues of ELECTRICAL ENGINEERING.

Michigan's Largest Dam

HARDY DAM on the Muskegon River supplies the Consumers Power Company over a 48-mile 140-kv. transmission line to Grand Rapids, Michigan. This dam is the largest in Michigan, and among the largest earth dams in the world built on an earth foundation. The dam itself is about 100 ft. high and the pond created has a volume of 160,000 acre ft. The three fully automatic generators are of the vertical type, each rated at 12,500 kva. 60 cycles. Direct-connected main and auxiliary exciters are mounted above the main thrust bearing. The thrust bearings on the generators carry the load of the generator rotors, the waterwheel and the hydraulic thrust of the water passing through the wheel, amounting to a total of approximately 290,000 lb. The generators are enclosed completely and are equipped with water tube air cooling condensers, located below the operating floor which is at exciter level.

A.I.E.E. Prizes for Technical Papers

Authors who are presenting papers before the Institute during the calendar year 1932, and others who may wish to submit papers for prizes, would do well to bear in mind that such papers are eligible for consideration for Institute prizes. These awards are made each spring for the preceding calendar year, and fall into two main classes. national and District prizes.

National Prizes

The national prizes which may be awarded at the discretion of the committee on award of Institute prizes are as follows:

1. Prizes for best papers in (1) *engineering practise*, (2) *theory and research*, and (3) *public relations and education*
2. Prize for initial paper
3. Prize for Branch paper

Each national prize shall consist of a certificate of award issued by the Institute and $100 in cash.

The national prize for best paper in each of the three classes indicated may be awarded to the author or authors of the best original paper presented at any national, District, or Section meeting of the Institute.

The national prize for initial paper may be awarded to the author or authors of the most worthy paper presented at any national, District, or Section meeting of the Institute, provided the author or authors have never previously presented a paper which has been accepted by the technical program committee.

The national prize for Branch paper may be awarded to the author or authors of the best paper based upon undergraduate work presented at a Branch or other Student meeting of the Institute, provided the author or authors are Student Branch members.

All papers submitted for prizes (except for the Branch paper prize) must be written by members of the Institute. When papers are written jointly, the cash awards shall be divided, and a certificate shall be issued to each author.

All papers approved by the technical program committee which are presented at any meeting will be considered by the committee on award for the best paper prizes without being formally offered for competition. All papers other than those presented to the technical program committee must, in order to receive consideration, be submitted in triplicate with a written communication to the national secretary on or before February 15 of the year following the calendar year in which they were presented. This may be done by the author or authors, by an officer of the Institute, or by the executive committees of Sections, or Geographical Districts.

District Prizes

The following District prizes may be awarded each year in each Geographical District of the Institute.

1. Prize for best paper
2. Prize for initial paper
3. Prize for Branch paper

Each District prize shall consist of a certificate of award issued by the officers of the Geographical District and $25 in cash. It may be awarded only to an author who, or to co-authors of whom at least one, is located within the District, and for a paper presented at a meeting held within, or under the auspices of, the District. When papers are written jointly, the cash awards shall be divided and a certificate shall be issued to each author.

The District prize for best paper may be awarded for the best paper presented at a national, District, or Section meeting.

The District prize for initial paper may be awarded for the best paper presented at a national, District, or Section meeting, provided the author or authors have never before presented a paper before a national, District, or Section meeting of the Institute.

The District prize for Branch paper may be awarded for the best paper based on underground work presented at a Branch or other Student Meeting of the Institute, the author or authors of which are Student Branch members.

All papers to be considered in competition for District prizes must be submitted in duplicate by the authors or by the officers of the Branch, Section, or District concerned to the District committee on awards on or before January 10 of the year following the calendar year in which the papers have been presented.

All papers submitted for prizes (except for the District prize for Branch paper) must be written by members of the Institute. When papers are written jointly at least one of the authors must be a member of the Institute.

Copies of a pamphlet entitled "National and District Prizes" may be secured, without charge, upon application to Institute headquarters.

Federal Radio Act Passes Senate.—On January 4, 1932, the U. S. Senate passed Senate bill 1,037 which would amend the federal radio act of 1927 so as to transfer the existing radio division from the Department of Commerce to the Federal Radio Commission. This is a reorganization measure which will consolidate and simplify the federal government's activities in regulation of radio matters.

Montefiore Award to be Made Soon

Announcement has been made of the conditions of the George Montefiore prize which will be awarded this year by the Institut Electrotechnique Montefiore of Liege, Belgium. The prize consists of the interest on 150,000 Belgian francs at 3 per cent and is given triennially in international competition for the best original work presented on scientific advancement or on progress in the technical application of electricity in any field. Only achievements made public during the three years preceding the award will be considered. Manuscripts may be submitted in English, in printed or typewritten form, and must be in the hands of the jury not later than April 30, 1932.

The awarding of the prize is in the hands of a jury of ten electrical engineers composed of five from Belgium and five from other countries, acting under the president of the Institute Electrotechnique Montefiore, Omer De Bast. The award is administered through the Association des Ingenieurs Electriciens, or national electrical engineering society of Belgium, with headquarters at Rue Saint Gilles, 31, Liege, Belgium.

Bibliography on Conductor Vibration

The subcommittee on steel transmission towers and conductors of the power transmission and distribution committee has been working on the problem of vibrating and dancing conductors. As a method of assisting research in this problem, a bibliography has been prepared on vibration, using this term in its broader interpretation.

In compiling this bibliography, all literature available both in this country and abroad has been reviewed to give as complete a reference as possible on this subject. There are six general headings under which these articles have been grouped and which also indicate the relation of associated problems. These six classifications are:

1. Vibration in electrical cables exposed to light winds.
2. Jumping or dancing conductors due to partial glaze coatings and varying ice formations.
3. Wind effects on structures.
4. Wire rope research.
5. Sound and noise.
6. Fatigue and allied researches.

This bibliography is now in mimeographed form and contains a total of 176 items. Any investigators working on this subject may obtain a copy from the chairman of the subcommittee, R. N. Conwell, Public Service Electric and Gas Co., 80 Park Place, Newark, N. J.

Columbia University Offers E.E. Scholarships

Each year the governing bodies of Columbia University have placed at the disposal of the Institute a scholarship in electrical engineering in the school of mines, engineering, and chemistry of Columbia University, for each class. The scholarship pays \$350 toward the annual tuition fees which vary from \$340 to \$360 according to the details of the course selected. Reappointment of a student to the scholarship for the completion of his course is conditional upon the maintenance of good standing in his work.

Applicants must meet the regular admission requirements. All letters of application should be addressed to F. L. Hutchinson, National Secretary, A.I.E.E. 33 West 39th St., New York, N. Y., and should give age of candidate, place of birth, education, references, photograph, and reference to any other activities, such as athletics or working one's way through college. The last day for filing applications for the year 1932-33 will be June 1, 1932.

The course at the Columbia School of Mines, Engineering, and Chemistry is a three-year course on a graduate basis. Candidates must have had a general education including considerable work in mathematics, physics, and chemistry. Three years of preparatory work with special attention to the three preparatory subjects mentioned in a good college or scientific school should be sufficient. A college graduate with a B.S. degree in engineering generally can qualify to advantage. The candidate is admitted on the basis of his previous collegiate record without undergoing special examination. Other qualifications being equal, members of Student Branches of the A.I.E.E. will be given preference.

The purpose of this advanced course is to produce a high type of engineer, trained in the humanities as well as in the fundamentals of his profession. It is hoped that Enrolled Students and others qualified will show a keen interest in this scholarship.

A windowless building, the first of its kind in the United States, is under construction at Fitchburg, Mass., for the Simonds Saw & Steel Company by the Austin Company of Toledo, Ohio. With solid wall and roof construction and with neither windows nor skylights this new industrial plant is planned to contain 5 acres of floor space and designed to cover practically two city blocks. Francis Keally, New York, is the architect responsible for the design of this \$1,500,000 plant, and predicts greatly superior working conditions within the new structure as compared with the more usual design. Elaborate systems to provide high intensity lighting, regulated ventilation absorption of interior noise and elimination of exterior noise are expected to be installed in the building. The lighting system is planned to supply

Construction Progresses for World's Fair

THIS interesting study of part of the electrical group of "A Century of Progress," Chicago's 1933 World's Fair, gives an idea of the rapid progress being made in its construction. When completed, this group will comprise three buildings, a radio building, a communications building and an electrical building. The group will join the mainland site of the exposition by a bridge. In the background of this picture may be seen a view of the 1933 World's Fair site, from the Hall of Science at 16th Street north to the Shedd Aquarium.

a proportion of ultraviolet radiation and a harmonizing color scheme for machinery, and interior decoration is expected to complete the provision of excellent working conditions.—*Michigan Technic.*

N.E.L.A. Relay Handbook Reissued With Supplement

The Relay Handbook, originally issued by the National Electric Light Association in 1926, has just appeared in its second edition as "Relay Handbook and Supplement." It was thought best, by the subcommittees of the N.E.L.A. and the protective devices committee of the A.I.E.E. concerned with the revision of the original publication, to bring the book up to date by the addition of supplements to the several sections. All material contained in the supplements is believed to be new and all new relay schemes described have been tested in service unless stated to the contrary.

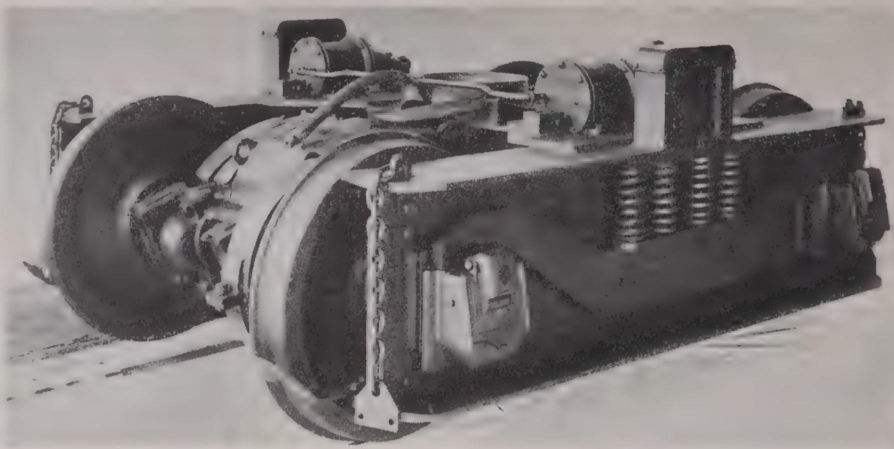
With regard to "Section I—General Information," it should be kept in mind that while the supplement is devoted entirely to a presentation of the latest symbols used in practise for electric power and wiring, and shortly to be offered for approval as an American Standard, this does not carry with it the inference that the definitions also contained in Section I of the 1926 edition and taken from the 1922 edition of the A.I.E.E. Standards have remained unchanged since that date. Reference to the latest standards of the A.I.E.E. should be made whenever use of the definitions is contemplated. For complete information relative to this handbook apply to N.E.L.A. headquarters, 420 Lexington Avenue, New York, N. Y.

Lightning Arresters Tested at High Energy

A test has been made which is stated to be the first ever performed on a full size high voltage lightning arrester with surge energy comparable to that met in the field. The newly installed 3,000,000-volt 36,000-watt-second lightning generator at the Sharon Works of the Westinghouse Electric & Manufacturing Company was used in this test.

A 230-kv. station type auto-valve arrester, such as would be used for the protection of 230-kv. transformers, was set up in parallel with the 64-in. relief gap recommended for this voltage class, and a string of fourteen suspension insulators. Surges of various magnitudes and steepness of front were applied from the 3,000,000-volt surge generator. Finally, the full output of the surge generator was discharged through the arrester, the wave front being about three times as steep as the steepest lightning surge yet recorded in the field. The lightning arrester prevented flashover of the 64-in. coordinating relief gap in all cases. In the last test described above, between fifteen and twenty thousand amperes passed through the lightning arrester. However, it is claimed that careful examination showed the arrester to be unharmed.

An All-Welded Switching Locomotive



The complete structure of cab, under-frame, and trucks of seven locomotives constructed by the General Electric Company for switching service at Bush Terminal, Brooklyn, N. Y., is fabricated entirely from structural steel shapes and plates, and is arc welded throughout. There are no rivets, and bolts have been used only for those portions requiring occasional removal or renewal. One of the trucks, with motors installed, is shown in the illustration. Each locomotive is of the 60-ton type and has a Diesel-electric power plant, using a 300-hp. engine. The truck frame consists essentially of three members: two side frames of 26-in. 151-lb. girder beams with a 22-in. 108-lb. girder beam serving as the bolster. The bolster beam is welded directly to the side members, the joint surfaces being reinforced with heavy gusset plates and brace plates. All welds on these members are continuous. On the cab, both continuous and intermittent welding are used.

Joint Meeting on Metals.—On Feb. 18, 1932, Sections of the American Society for Testing Materials and the American Institute of Mining and Metallurgical Engineers will hold a joint meeting in the auditorium of the Engineering Societies Building, 33 West 39th Street, New York, N. Y. The general theme of the meeting will be metals; Dr. F. O. Clements will discuss the subject "Limits of our Knowledge of the Properties of Metals," and Prof. H. F. Moore will address the meeting on "Test Results and Service Values of Metals." From long and active connection with the metals field, both of these men are qualified to discuss these subjects ably and with authority. All interested in the subject of metals are cordially invited to attend. The meeting is scheduled to begin at 8 p.m.

Graduate Courses in Acoustics and Physics.—Beginning on February 5, 1932, two new graduate courses will be given on Friday evenings at the Polytechnic Institute of Brooklyn, New York. They will be given by Prof. R. B. Lindsay, visiting professor of theoretical physics from Brown University, and are entitled "Acoustics" and "Statistical Theories in Modern Physics."

The course in acoustics will begin with a rapid review of the simpler properties of sound waves and will proceed through the development of fundamental mathematical theory to the more important practical problems. The second course will include an introduction to the use of statistical methods in physics, followed by a presentation of the new statistics of Bose-Einstein and Fermi-Dirac. The latter viewpoints will be applied to the more important electrical and thermal problems. While the treatment will be mathematical, the principal emphasis will be upon the physical significance of the results.

American Engineering Council

Annual Meeting and Election of Officers

At the annual meeting of the American Engineering Council in Washington, D. C., January 14-16, 1932, W. S. Lee (A'04, F'13, past-president) of Charlotte, N. C., was elected president for the coming two years. He succeeds C. E. Grunsky of San Francisco, Calif. Gen. R. C. Marshall, Jr., and L. B. Stillwell (A'92, F'12, past-president) both of New York, N. Y., were respectively elected and reelected vice-presidents. Farley Osgood (A'05, F'12, past-president) of New York, N. Y., was named treasurer to succeed Dr. H. E. Howe of Washington, D. C.

The following representatives of the Institute were designated to serve on the administrative board of the Council for the year 1932: C. O. Bickelhaupt, H. A. Kidder, R. F. Schuchardt, C. E. Skinner, and C. E. Stephens.

Administration of Public Works

Steps also were taken at the annual meeting to aline the engineering profession in support of legislation to create an administration of public works in accordance with the recommendation of President Hoover in his last message to Congress.

The Council will work for the enactment by the present Congress of the bill introduced in the House by Representative Cochran of Missouri "to accelerate public construction in periods of business depression through the creation of an administration of public works and to provide for a more effective coordination and correlation of the public works functions of the government." Numerous amendments to the Cochran measure will be urged upon Congress by the engineers.

The Council has been advocating public works reorganization since it was founded in 1919 under the leadership of Mr. Hoover. Favorable action by Congress now is believed to be probable owing to the disappointment of the people over the failure of public works activity to provide the measure of unemployment relief which had been expected. The taxpayers, it is believed, are aroused to the point where they will demand such a realinement of public works bureaus and services as will respond to national needs in times of economic distress.

Passage of this legislation, it was asserted in the Council's discussion, will be a large factor in bringing about economies in the federal administration and in balancing the federal budget. Presidential sponsorship of public works consolidation will, it was felt, evoke a sympathetic response from both parties in Congress inasmuch as the ends sought are non-political. Many millions of dollars annually will be saved if the public works proposal becomes law, it is held.

The Cochran bill provides for the appointment by the President of an administrator of public works to hold office for fifteen years at an annual salary of $15,000, and for the establishment in the administration of public works of a group of bureaus, each headed by a director, to administer the various public works services.

Requirements of Administrator

The Council will ask Congress to require that the administrator "shall by training and experience be qualified to administer the affairs of the administration of public works and to evaluate the technical principles and operations involved in the work thereof."

On the motion of L. B. Stillwell (A'92, F'12, past-president) of New York, N. Y,. the Council voted opposition to the plan to place the national commission of fine arts under the jurisdiction of the administration of public works. Inclusion of the commission in the administration, Mr. Stillwell said, might deprive the government of the patriotic service of the nation's leading architects.

The engineers will seek an amendment to the Cochran bill placing the design, construction, maintenance, operation and repair of ferries, barges, hospitals, lighthouses, prisons, storehouses, docks, and flood control works under the control of the administrator of public works.

Another engineering amendment would enable the administrator to employ from time to time, outside professional or technical service of competent persons, firms, or corporations, for the architectural and engineering designing, planning and construction of such federal buildings and works as may be placed under his jurisdiction.

Enlargement of the authority of the administrator of public works is asked by the Council in the following amendment:

"Under the direction of the President, the administrator of public works shall have the power by order or regulation, to consolidate, eliminate, or redistribute the functions of the bureaus, offices, agencies, activities and services in the administration of public works and to create new ones therein and by rules and regulations not inconsistent with law, shall fix the functions thereof and the duties and powers of their respective executive heads."

In adopting the public works program, the Council acted upon the recommendations of the public affairs committee headed by R. F. Schuchardt (A'03, F'13, past-president) of Chicago, Ill.

Green Bill

The Council sanctioned the measure introduced by Representative Green and sponsored by the American Institute of Architects, authorizing the Secretary of the Treasury to employ private architects in the designing and planning of public buildings. Engineers, however, would make the employment of private architects optional with the Treasury instead of mandatory as provided in the bill. Gen. R. C. Marshall, Jr., of New York, N. Y., head of the construction division of the War Department during the World War, declared that the principle of the bill should apply to all government agencies. The Fulmer bill, which is along the same lines as the Green bill, was opposed. Neither measure would be necessary if the Cochran bill becomes law.

Representatives of the American Institute of Electrical Engineers in attendance were: F. J. Chesterman, W. S. Lee, I. E. Moultrop, Farley Osgood, W. S. Rodman, R. F. Schuchardt, C. F. Scott, C. E. Skinner, and L. B. Stillwell.

Patents Committee Invites Public Hearings

The patents committee of the House of Representatives is holding public hearings in Washington from January 20, 1932 to March 1, 1932. As indicated in the following four paragraphs taken from a letter under date of January 8, 1932, from W. I. Sirovich, chairman of the committee on patents of the House of Representatives, to L. W. Wallace, executive secretary of the American Engineering Council, the purpose of these hearings is to assist the committee in planning legislation that will meet the approval of the Congress of the United States.

"Many bills are introduced at each session of Congress for the purpose of amending the patent laws, nevertheless they remain substantially as they were enacted in 1836. As chairman of the committee on patents and copyrights of the House of Representatives of the 72nd Congress, I desire to learn whether the changed economic conditions require amendment, or change, in our patent statutes. To that end I propose to have public hearings before the committee on patents at Washington from January 20, 1932 to March 1, 1932.

"You are cordially invited to attend and give the committee on patents the benefit of your opinion as to what, if any, legislation should be enacted.

"Will you please give this communication as much publicity as possible and invite members of your organization, and any officers or committees interested, to appear before the committee and indicate what, if any, legislation should be enacted.

"As far as possible I wish to meet the convenience of those not residing in Washington, and a definite date for appearance before the committee may be arranged by writing me, indicating how much time is wanted and about when."

College Course in Radio Offered.—Through its extension division in Milwaukee, the University of Wisconsin is giving a course in radio communication. This training is of a semi-professional nature with the object of training young men for positions existing in a field between the skilled craftsman and the trained professional engineer. The work is substantially of collegiate grade requiring for entrance a high school education or the equivalent. Completion of the course requires the full time of a student for two semesters, or evening classes over a period of two years. The course may be taken by correspondence also. Satisfactory completion qualifies a student for the government examination for a second-class commercial operator's license.

Ambrose Swasey (HM'28) was honored on his eighty-fifth birthday by a luncheon tendered him by officers of the Cleveland (Ohio) chamber of commerce on December 19, 1931. On this occasion about a hundred letters of congratulation were presented to him, and a preview of the Swasey portrait painted by Philip A. de Laszio was made. Among the speakers was Dr. C. W. Rice (A'97-F'12) who paid tribute to Mr. Swasey's many contributions.

Letters to the Editor

Discussion of "E.E." Articles Invited

Institute members and subscribers hereby are invited to discuss in these columns any of the articles appearing in Electrical Engineering. Heretofore discussion has been solicited specifically only on those articles appearing in the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?" Nevertheless, since the introduction of these columns in the September 1931 issue, some readers already have sent in letters on other articles, a few of which were published in subsequent issues.

Because of the many letters received, it is not feasible to publish all, but an endeavor will be made to include those which appear to be of the most general interest. The shorter letters in general are more popular, and hence conciseness is a desirable quality in all cases. Electrical Engineering reserves the right to publish letters either in full or in part.

Warning to Welders

To the Editor:

I hope you will feel it your duty to issue this warning to welders:

They should not light their cigarettes or cigars from the glowing tip of the electrode when it is still in the electrode handle. This is a very clever or handy trick but some day when their cigarette is damp or their shoes are damp they will get a shock. This can best be described as if a mule kicked them in the jaw and loosened all their teeth. Such a shock might prove fatal if they are working on a scaffold or in a tank or some such place where the release of the tension would throw them off balance. It is always spoken of as "a shock throws one." As a matter of fact, it is the cutting of the rope which you have been straining against trying to release yourself from the muscular tension that "throws you."

Very truly yours,
C. J. HOLSLAG (M'19)
President, Electric Arc Cutting & Welding Co., 152 Jelliff Avenue, Newark, N. J.)

Nerve Injuries from Electric Shock

To the Editor:

I should like to enter protest against the inclusion in Electrical Engineering of further articles of the type exemplified by "Nerve Injuries from Electric Shock" in the December 1931 issue. I do not believe the average engineer is interested in a subject so remotely connected with engineering.

I suppose the medical journals will still be filled with this class of work, but I do not believe it belongs in quantity in our transactions. It is bad enough to use rats in this work; if we ever use dogs it were better for us if we passed out of existence as a body at that time. I do not believe that kind of engineering is acceptable "On High," and I hope it will not be popular here below.

Pardon if my sincerity has carried me too far.

Yours very truly,
F. G. STRONG (A'91-F'13 and Life Member) 120 Hartford Ave., Wethersfield, Conn.

Computing the Value of $\sqrt{2}$

To the Editor:

Having an occasion to compute the value of the form-factor of sine wave ($\pi/2\ \sqrt{2}$) to the fifth place of decimals, I felt interested in developing some simple method of computing the value of $\sqrt{2}$, to a high degree of precision. The following two methods evolved in the course of the study might interest some of your readers:

Method 1—Expansion into a rapidly convergent series:

$$2 = \frac{100}{49}(1 - 0.02)$$

therefore

$$\sqrt{2} = \frac{10}{7}(1 - 0.02)^{\frac{1}{2}}$$

By the binomeal theorem

$$\sqrt{2} = \frac{10}{7}\Big[1 - \Big(a + 1/2\,a^2 + 1/2\,a^3 + 5/8\,a^4 + 7/8\,a^5 + \frac{21}{16}a^6 + \frac{33}{16}a^7 + \ldots\ldots \frac{1 \times 3 \times 5 \times 7\ldots(2n-3)}{(1 \times 2 \times 3 \times \ldots\ldots n)}a^n\Big]$$

where
$a = 0.01$
or

$$\begin{aligned}\sqrt{2} = \frac{10}{7}[1 - 0.01 & \\ & 0.00005 \\ & 0.0000005 \\ & 0.00000000625 \\ & 0.00000000000875 \\ & 0.000000000000013125 \\ & 0.0000000000000020625 \quad \text{etc.}]\end{aligned}$$

$$= \frac{10}{7}\left\{1 - (.010050506338833\mathit{125}\ldots)\right\}$$

$$= \frac{10}{7}\left\{0.989949493661166\mathit{875}\ldots\right\}$$

therefore

$$\sqrt{2} = 1.41421356237309\mathit{553}\ldots$$

and

$$\sqrt{\frac{1}{2}} = \frac{1}{2}\sqrt{2} = 0.707106781186547\mathit{765}$$

For the first seven terms of the series the computation is very simple as illustrated above; beyond this point it begins to be more laborious. Using the first three terms of the series only, the computation can be made almost mentally, giving the result correct to seven places of decimal. Numerals in italics are inaccurate due to omission of terms of higher order.

$$\sqrt{2} = \frac{10}{7}(1 - 0.0100505)$$

$$= \frac{10}{7}(\quad 0.9899495)$$

$$= \quad 1.41421357$$

Even this is much more accurate than the requirement of the original problem.

Method 2—Approximating fraction; consider the following series of fractions:

$\frac{1}{1}$	$\frac{2}{3}$	$\frac{5}{7}$
$\frac{12}{17}$	$\frac{29}{41}$	$\frac{70}{99}$
$\frac{169}{239}$	$\frac{408}{577}$	$\frac{985}{1393}$
$\frac{2378}{3363}$	$\frac{5741}{8119}$	$\frac{13860}{19601}$
$\frac{33461}{47321}$	$\frac{80782}{114243}$	$\frac{195025}{275807}$
$\frac{470832}{665857}$	$\frac{1136689}{1607521}$	$\frac{2744210}{3880899}$
$\frac{6625109}{9369319}$	$\frac{1599428}{22619537}$	$\frac{38613965}{54608393}$
$\frac{93222358}{131836323}$	$\frac{225058681}{318281039}$	$\frac{543339720}{768398401}$
$\frac{1311738121}{1855077841}$	$\frac{3166815962}{4478554083}$	$\frac{7645370045}{10812186007}$
$\frac{18457556052}{26102926097}$	$\frac{44560482149}{63018038201}$	$\frac{107578520350}{152139002499}$
etc.	etc.	etc.

Each fraction of the above series represents the value of $\sqrt{1/2}$, and when inverted represents the value of $\sqrt{2}$, each subsequent fraction being a closer approximation than the one before. This is most easily verified by squaring any of the above fractions. For example, the squares of the first two rows are:

$$\frac{1}{1} \quad \frac{4}{9} \quad \frac{25}{49} \quad \frac{144}{289} \quad \frac{841}{1641} \quad \frac{4900}{9801}$$

These square fractions are all approximately equal to 1/2, the denominator being in each case equal to twice the numerator, ± 1. This rule applies to all the subsequent fractions.

Each fraction is obtained from the previous fraction by the following procedure:

1. Add the numerator and denominator of any fraction; this gives the numerator of the next fraction.
2. Add this numerator of the new fraction to the numerator of the previous fraction; this gives the denominator of the new fraction.

For example, starting with the fifth fraction (29/41), we get $29 + 41 = 70$, this is the numerator of the next fraction; $29 + 70 = 99$, this is the denominator of this new fraction; this makes the sixth fraction 70/99. For practical use it is not necessary to go beyond the twelfth fraction, which gives the values correct to the eighth place of decimal, *viz.*, $\sqrt{2} = 1.414213564$, and $\sqrt{1/2} = 0.707106782$.

To obtain the fractions of higher order, it is not necessary to go through all the intermediate fractions. If m/n be the fraction of the mth order, the fraction of $2\,m$th order is, $2\,m\,n/(4\,m^2 + 1)$, if m is an even figure. For example, the sixth fraction is 70/99; therefore, the twelfth fraction is $2 \times 70 \times 99/(4/70^2) + 1 = 13860/19601$; the twenty-fourth fraction is $2 \times 13860 \times 19601/(4.13860^2 + 1) = 543339720/768398401$; and so on.

The purpose of this letter is not merely to determine accurately the value of $\sqrt{2}$, but to introduce a new and interesting aspect of the theory of numbers. The series has many other interesting properties which need not be discussed in this letter.

Very truly yours,

S. L. GOKHALE (M'20)
General Engineering Lab.,
General Electric Co., Schenectady, N. Y.)

Engineering Foundation

Research Procedure Committee Appointed

With the approval and assistance of the Founder Societies, The Engineering Foundation has appointed a research procedure committee composed of one representative from each Founder Society selected from or designated by its main research committee annually, and nominated to the Foundation by its governing board or duly authorized officer, and two members of the Foundation Board.

The members appointed for the year 1932 are Thaddeus Merriman, representing the A.S.C.E., F. M. Becket, representing the A.I.M.E., W. H. Fulweiler, representing the A.S.M.E., L. W. Chubb, (F'21) representing the A.I.E.E., and E. DeGolyer and D. R. Yarnall, members of the Foundation board. The duties of this committee will be to aid the Foundation in ascertaining and meeting the research needs of its Founder societies and in making intelligent selections among the numerous projects in which the four societies are interested individually and collectively.

Personal

Honorary Membership Awarded Frank J. Sprague

On December 4, 1931, the board of directors elected Frank J. Sprague (A'87, F'12, past-president) an Honorary Member of the American Institute of Electrical Engineers. This is the highest grade of membership in the Institute and is held by only seven other Americans and three representatives of foreign countries.

Underwood & Underwood

F. J. SPRAGUE

The petition, previously presented to the board, is as follows:

"The undersigned Members and Fellows of the American Institute of Electrical Engineers propose for Honorary Membership, Dr. Frank J. Sprague, as the outstanding pioneer in the development of electric traction. We respectfully request the board to give the name of Dr. Sprague early consideration for this honor."

The following statement was also included with the petition:

"Dr. Sprague was not only the originator of the first successful electric traction, but had the same distinction in regard to the electric elevator. His invention of multiple unit train control was also a work of great importance."

Dr. Sprague has long been outstanding in the profession. He was born at Milford, Conn., July 25, 1857, and in 1878 graduated with honors from the U.S. Naval Academy. On his return in 1880 from a tour around the world as midshipman, he attempted to introduce electric light into the navy. He was ordered to the Crystal Palace Exposition, London, England, in 1882, as a member of the jury and in charge of tests on dynamo-electric machines, gas engines, and electric lights.

Dr. Sprague resigned from the navy in 1883 to take up electrical work, and was an assistant to Mr. Edison in the early development of the electric light. In 1884 he founded the Sprague Electric Railway and Motor Company, and pioneered in the development of electric motors and their application to industrial use. His pioneer work in electric traction followed and under his direction a trolley railway was built at Richmond, Va. in 1887 which well can be called the forerunner of the modern electric railway. Pioneer railway installations also were made in Italy and in Germany. These were followed by many similar systems throughout the world. Dr. Sprague also was active in the introduction of electric high speed and house automatic elevators, founding companies for the carrying on of this activity. In 1895 he invented the multiple-unit system of electric train control which now is so extensively used where two or more locomotive units are under common control. He has been an active advocate of underground rapid transit throughout the whole period of its development in New York City.

He is now president of the Sprague Development Corporation and the Sprague Safety Control and Signal Corporation; and is consulting engineer of the Westinghouse and General Electric companies. As consulting engineer for the Southern Pacific Company he made studies for the electrification of the Sierra-Nevada section of that system.

Dr. Sprague has long been active in Institute affairs, having served on various committees, as well as having been vice-president (1890-92) and president (1892-3). He was selected by both the Institute and the Inventors Guild as a member of the U.S. Naval Consulting Board, and engaged during the World War in the development of fuses, and air and depth bombs. He is also a member and past-president of the New York Electrical Society, the American Institute of Consulting Engineers, and the Inventors Guild; a member of the American Society of Civil Engineers, the New England Society, the New York Historical Society, Ye Old Settlers, the Institution of Electrical Engineers and Institution of Civil Engineers of England; an honorary member of the Franklin Institute and National Electric Light Association; and an associate member of the Society of Naval Architects and Marine Engineers. He was awarded the Gold Medal of the Paris Exposition (1889) for electric railway de-

velopment; the Elliott Cresson Medal of the Franklin Institute (1904) for the multi-unit system; the Grand Prize for "invention and development in electric railways" at the St. Louis Exposition (1904); the Edison Gold Medal of the Institute "for meritorious achievement in electrical science, engineering and art" (1910); and the Franklin Medal (1921) "for fundamental inventions and achievements in electrical engineering." Dr. Sprague is a member of the University, Century, Bankers, and Railroad clubs.

Everett S. Lee (F'30) recently appointed by the General Electric Company, Schenectady, New York, to succeed L. T. Robinson (F'12, deceased) as engineer in charge of the general engineering laboratory, a position of significant responsibility, has served the profession in various representative capacities ever since his graduation from the University of Illinois in 1913. Immediately following graduation, he entered the G.E. test department. Later he went to Union College as an instructor in electrical engineering; his masters degree being awarded him there in 1915. During the war period he returned with a commission of first lieutenant to the University of Illinois as instructor in machine gunnery in its school of aeronautics. Upon his return to civilian duties, he was placed in charge of meters and instruments in the general engineering laboratory of the General Electric Company, later to be made assistant director, the position from which he arrived at his present promotion.

Mr. Lee has served the Institute diligently in the varying capacities of chairman of the A.I.E.E. Schenectady Section (1928-29); Sections committee (1929-32); meetings and papers committee (1927-30); instruments and measurements committee (1927-32, chairman 1927-30); coordination of Institute activities committee (1930-32); and upon the special committee on Institute policies (1931—). He is a member of Tau Beta Pi, Eta Kappa Nu, and Sigma Xi fraternities and also of various honorary engineering and scientific societies.

F. W. Clements (A'08) formerly state electricity commissioner of Victoria, Australia, has been appointed chairman of the state electricity commission to succeed the late Sir John Monash. Mr. Clements was born in Halstead, Essex, England in 1862, being educated in the public schools in London and also in Germany. His technical education was obtained at the City Guild College, London, supplemented by training at the Great Eastern Railway Works, and the Brush Company, both of London. Between 1881 and 1890 he was with the Brush Company in various capacities, including service as their representative in Hungary, and joint manager of their factory and contract department in Vienna. He later held positions in England, and in 1899 went to Australia being engineer and manager of the Electric Lighting and Traction Company of Australia, later local managing director and chief engineer of the Adelaide Electric Supply Company, South Australia. Mr. Clements later held responsible positions with other Australian companies prior to becoming state electricity commissioner. He is a member of the Institution of Electrical Engineers and the Australian Institute of Engineers.

G. C. Ward (M'24), for the last three years executive vice-president of the Southern California Edison Company, Ltd., Los Angeles, Calif., recently was elevated to the rank of senior vice-president of this company. Born in White Plains, N. Y., January 9, 1863, Doctor

E. S. LEE

Ward was educated at Philips Academy, Andover, Mass., and between 1882 and 1902 was location and construction engineer for the following railroads: New York, West Shore and Buffalo; Erie; New York Central; Delaware and Hudson; and Mohawk and Malone. Between 1902 and 1911 he was associated with H. E. Huntington in the Pacific Electric and the Los Angeles railways. Following this he was president of the Pacific Light and Power Corporation, until that company was merged with the Southern California Edison Company in 1917. He then became vice-president in charge of construction and operation of the latter company, and continued in this position until being advanced to executive vice-president three years ago. Under Doctor Ward's generalship the well known engineering developments of his companies have been carried out, starting with the Big Creek plant and continuing through the completion of some 500,000 hp. in steam-electric generating capacity at Long Beach. The University of Southern California has honored him with the degree of doctor of engineering, and Oberlin College has conferred the degree of doctor of science upon him.

Sidney Hosmer (F'12) vice-president and L. L. Edgar (A'12) vice-president and assistant superintendent, of the Edison Electric Illuminating Company of Boston, Mass., have advanced to the respective offices of vice-president and assistant general manager, and vice-president in charge of the operating bureau; I. E. Moultrop (F'29 and vice-president) the company's chief engineer, now has been appointed head of its construction bureau. All three of these men are well known as veterans in the utility's employ. Mr. Moultrop has served also as chairman of the Institute's Boston Section, as a member of the Boston Society of Civil Engineers, the National Electric Light Association, the American Standards Association, and vice-president of the American Engineering Council. He long has been a member of the A.S.M.E. power test and boiler code committees, and was on that society's Council three years as manager and two years as vice-president.

M. P. Rice (M'19) manager of publicity, General Electric Company, Schenectady, N. Y., retired as of December 31, 1931, leaving behind him a record of over 37 years of valuable service to the company. It was Mr. Rice himself who in 1903 established the General Electric Review, the company's technical magazine. Under his direction too, the Maqua Company, which produces much of the company's printed matter, was started. In 1921 when the company became interested in radio broadcasting, he was made director of the activity and in this position not only outlined the company's policy in this new field, but also established its three broadcasting stations at Schenectady, N. Y., Oakland, Calif., and Denver, Colo.

C. J. Fechheimer (F'14) previously of the power engineering department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has opened his own consulting engineering offices in the Title Guaranty Building, Milwaukee, Wis. Those interested in the development of electrical machinery will recall Mr. Fechheimer as the author of technical literature on this subject. At present he is extending his work in this field by giving a course of lectures on thermal problems in electrical machinery under the auspices of the Milwaukee Extension Division of the University of Wisconsin.

H. W. Bibber (M'30) on January 1, 1932, left the central station engineering

department of the General Electric Company, Schenectady, N. Y., to become associate professor of electrical engineering at Ohio State University. This is not Mr. Bibber's first teaching experience; he was instructor in electrical engineering at Massachusetts Institute of Technology following his return from studies in Ecole Superieure d'Electricite, Paris, and he is a member of the Society for the Promotion of Engineering Education.

W. S. Lee (A'04, F'13, past-president) of Charlotte, N. C., was elected president of the American Engineering Council at its annual meeting in Washington, D. C., January 14-16, 1932. Mr. Lee, who succeeds C. E. Grunsky of San Francisco, Calif., will hold office for two years. At this same meeting L. B. Stillwell (A'92, F'12, past-president) was chosen to continue as vice-president, and Farley Osgood (A'05, F'12, past-president) of New York, N. Y., was named treasurer.

Roy Page (M'21) vice-president and general manager of the Nebraska Power Company, Omaha, Neb., recently was chosen a vice-president of the Citizens' Power and Light Company of Council Bluffs, Iowa. Mr. Page is representative in professional circles in Omaha, having served as president of the Nebraska Section of the National Electric Light Association and also as chairman of the engineering section of the N.E.L.A. Middle West division.

J. M. Gaylord (M'13) formerly chief electrical engineer of the U.S. Bureau of Reclamation, and more recently superintendent of hydro generation for the Southern California Edison Company, Ltd., at Pasadena, Calif., now has been appointed chief electrical engineer of the Metropolitan Water District of Southern California. He has spent forty years on the Pacific Coast and is a widely recognized authority on electrical engineering in its relation to water power.

C. A. Leland, Jr., (M'27) vice-president and general manager of the Des Moines Electric Light Company, the Des Moines Gas Company and the Iowa Power and Light Company has been assigned to the charge of the Kansas utility properties of the North American Light and Power Company. He will retain his supervision of the Iowa holdings, and will operate for the Kansas utilities with his headquarters in Des Moines.

J. J. Smith (A'19) an electrical engineer of the General Electric Company, Schenectady, N. Y., has been appointed to succeed E. S. Lee as one of the assistant engineers of the general engineering laboratory. His association with the company dates from 1916 when he joined its switchboard test department in Schenectady, subsequently going to Pittsfield in the transformer engineering department and returning to Schenectady in 1919.

F. W. Tuck (A'16) formerly with the Pacific Gas and Electric Company as construction foreman and more recently superintendent of electric and line construction for the Anchorage Light and Power Company, now is electrical engineer in charge of construction and operation for Benguet Consolidated Mining Company and chief load despatcher for the North Luzon Power Company, both in the Philippine Islands.

J. M. Donaldson (A'04) chief engineer of the North Metropolitan Electric Power Supply Company, Northmet House, Cannon Hill, England, recently was elected president of the Institution of Electrical Engineers of Great Britain. As the result of earlier engineering work in the United States and Canada, Mr. Donaldson's worth as a professional man is recognized in this country as well as in England.

C. M. Brentlinger (M'27) formerly in the executive offices of the Western Union Telegraph Company, New York, N. Y., on December 1, 1931 was appointed division traffic superintendent for the company's central division comprising the states of Missouri, Kansas, Iowa, Nebraska, Minnesota, and North and South Dakota. His headquarters will be at Omaha, Neb.

E. W. Schilling (A'29) secretary-treasurer of the Iowa Section (1931-2) is now assistant professor of electrical engineering at the Michigan College of Mining and Technology. As instructor at Iowa State College, he completed his work for his degree of master of science, which he was awarded in 1930. He now is working toward his doctorate.

John Bankus (A'20) electrical engineer, Portland Electric Power Company, won the local section prize in the A.I.E.E. Portland Section at the annual meeting held Dec. 8, 1931. His paper portrayed a method of determining economic voltage and cable size for underground transmission.

S. Q. Hayes (F'12) an engineer of the Westinghouse Electric and Manufacturing Company, consulting engineer for the City of Quito, Ecuador, in 1928, and for the Quito Electric Light and Power Company in 1931, recently returned from Ecuador as its vice consul in Pittsburgh, Pa.

W. E. Thau (M'21) who has been director of marine engineering for Westinghouse Electric and Manufacturing Company, New York City, now has gone to the company's office at Lester, Pa. with the new title of manager of the marine general engineering division.

Otto Hartig (A'31) who has been serving as factory engineer for the Eagle Electric Manufacturing Company, Inc., Brooklyn, N. Y., now is occupied with emergency work for the hospital department, New York City, as mechanical draftsman.

A. N. Geyer (A'21) for several years has been associated with the Utah Power and Light Company of Salt Lake City, as maintenance engineer; now he has gone to Seattle, Washington, to identify himself with the Woodward Governor Company.

John Mann (A'31) designer of reactors and accessories and consultant on construction for the Metropolitan Device Corporation, Brooklyn, N. Y., now is electro-acoustical engineer in the Photoelectric Research Laboratory, Inc., New York, N. Y.

Kennard Moss (Student Member) a recent graduate of Texas Agricultural and Mechanical College is now in the employ of the Gulf Refining Company's engineering department, Port Arthur, Texas. His friends may reach him at 100 Lakeshore Drive, that city.

Harold Watkins (A'27) who has been in the electricity department of the Public Works Department, Freetown, Sierra Leone, West Africa, now has been made chief electrical engineer for the government of Sierra Leone, as announced late in December.

W. J. Walker (A'17) who has been serving the General Electric Company at Schenectady, N. Y. in railway supply and renewal parts sales, transportation department, now has been transferred to the company's works at Erie, Pa., in like capacity.

R. W. Sorensen (F'19) professor of electrical engineering at the California Institute of Technology, Pasadena, Calif., has been selected to serve on the board of directors for the Metropolitan Water District of Southern California.

C. V. Bullen (A'23) has left the electrical engineering department of the University of Oklahoma, Norman, Okla. and is now in the department of electrical engineering of the Texas Technological College, Lubbock, Texas.

Sidney Simpson (M'27) chief assistant electrical engineer for the North Western Railway, Lahore, Punjab, India, now is deputy locomotive superintendent (elec-

trical) for the Eastern Bengal Railway, Kanchrapara, Bengal, India.

G. B. Pulham (M'27) for the last six years chief erecting engineer for the Metropolitan-Vickers Electrical Company, Ltd., in India, Burma, and Ceylon, leaves Calcutta February 1932 to return to England.

C. H. Cutter (A'28) district manager for the Pacific Electric Manufacturing Corporation at Seattle, Wash., has been appointed business manager for "R.P.M." the monthly paper of the Electric Club of Seattle.

A. F. Grenell (A'25) who for some time has been associated with the Bell Telephone Laboratories, Inc., New York, N. Y., now has gone to Honolulu on further engineering service for the laboratories.

M. Yonezawa (A'25) electrical engineer, Imperial Government Railways, Marunouchi, Tokyo, Japan, has been chosen as a lecturer at the Tokyo Technical University.

C. W. Warner (A'26) electrical engineer for the Florida Corporation at its Tallahassee office, recently was transferred to the company's St. Petersburg, Fla. office.

E. W. Starr (A'28) has removed from Elsmere, N. Y., to become instructor in electrical engineering at Cooper Union Institute of Technology, New York City.

M. P. Colony (A'23) assistant engineer of the Great Western Power Company, Sacramento, Calif., has joined the Pacific Gas and Electric Company, as estimator.

Kern Dodge (M'12) consulting engineer, Philadelphia, Pa., has been made director of public safety of Philadelphia.

Obituary

Lewis Starr Streng (A'04-F'26) vice-president in charge of operation for the Louisville Gas and Electric Company, Louisville, Ky., died December 24, 1931, after an illness of several months. He was born in that city in 1876 and was graduated from Massachusetts Institute of Technology in 1898 with a bachelors degree in electrical engineering. That summer he went into the General Electric Company's test department at Schenectady, remaining there until December. Several times his technical work was interrupted by ill health, but in 1899 he entered the employ of the Peoples Light and Power Company, remaining with its successors, the United Electric Company of New Jersey and finally was promoted to inspector and assistant engineer. This latter office he held also with the Public Service Corporation of New Jersey. In 1906 he returned to his native state as chief engineer of the Kentucky Electric Company. For the Louisville Gas and Electric Company he was first chief engineer, then general superintendent before his later elevation to the vice-presidency. Two years ago Mr. Streng was placed in charge of purchases. Besides his membership in the Institute, he also belonged to The American Society of Mechanical Engineers, the American Gas Association, National Electric Light Association, Association of Edison Illuminating Companies, Engineers and Architects Club of Louisville, Electric Club, Standard Country Club and Quindecim Club.

L. S. STRENG

Raymond Stanislous Masson (A'99) widely known western consulting electrical engineer and former president of the Needles (Calif.) Gas and Electric Company, died at his home in Los Angeles, Calif., December 17, 1931. As consulting engineer for the Henry E. Huntington properties in southern and central California, Mr. Masson directed the construction of the first 40,000-volt transmission line in California, a line built in connection with the Borel hydroelectric plant of the Pacific Light and Power Corporation, a Huntington property which later became a part of the Southern California Edison system. Mr. Masson was born in Hammondsport, N. Y. in 1870, and did not retire from active business until 1929, when he was forced to do so because of ill health. He was graduated from Lehigh University with the class of 1892. From July 1892 to June 1893 he worked for the Field Engineering Company of New York on the Buffalo Railroad and several suburban roads; also on the construction of machinery and underground systems. The next year he joined the Westinghouse Electric and Manufacturing Company, spending 18 months in the shops at Pittsburgh, Pa., six months as switchboard operator at Niagara Falls Power Company, and two years in the San Francisco office as district engineer and salesman. He was at one time president and general manager of the Culiacan, Sinaloa, Mexico Electric Company.

William Nesbit (A'02-F'29) northeastern engineering manager of Westinghouse Electric and Manufacturing Company prior to his retirement two years ago, died December 31, 1931, after a lingering illness. He was born January 20, 1876; in 1895 became assistant electrician of the Central Foundry Company, Lewisburg, Pa. and during 1897-8 he engaged in an apprentice course at the Westinghouse company's main office in East Pittsburgh. The following year he was placed in charge of transformer testing. In 1900 he became transformer designer for the company, and during the interim between that time and 1926 when he took his position as northeastern manager, he was successively sales engineer at the Syracuse office of the Westinghouse company, sales engineer in its New York office, and manager of the company's engineering division in New York. To technical literature he contributed the book "Electrical Characteristics of Transmission Circuits," a work used extensively as a college text-book as well as being generally recognized as of valuable service to transmission engineers. Its compilation covered a period of fifteen years and it was in its fourth edition after the distribution of 12,000 copies in use.

Bertram Philip Wilber (A'03) assistant designing engineer, New York Edison Company, Irving Place, New York, N. Y., died at his home in Great Neck, N. Y., the latter part of December 1931. He was born in Philadelphia on the first of March 1871, educated in the public schools of Philadelphia and New York, and in the College of the City of New York, where he took a mechanical course. This he followed by an apprenticeship in the machine shops of the Pennsylvania Railroad Company. When he became interested in electricity much of his elementary study was self-imposed. From 1894 to 1905 was spent in the employ of the New York Edison Company as draftsman, designer, and chief draftsman in the design and construction of power and substations; from 1906 to 1916 he was assistant electrical engineer for L. B. Stillwell, in charge of the drafting office on the design and construction of power

plants, factories, estimating, inspection, testing, etc. A year was spent with the Pratt Engineering and Machine Company in the construction of various chemical plants. He also served Westinghouse, Church, Kerr and Company as assistant engineer.

William Bryan Duncan (A'20) assistant professor of electrical engineering, Stanford University, Calif., died of pneumonia December 18, 1931. He was thirty-three years of age. Born at Fayetteville, Ark., his general technical education included one year at Stanford University prior to his employment by the San Joaquin Light and Power Company, Bakersfield, Calif. After several years of practical work with this company, he returned to Stanford and earned his bachelor's degree. Using summers and vacations for more work in practical fields, Professor Duncan continued at Stanford University, earning his E.E. degree and at the same time gaining valuable knowledge in actual experience of application. With a change of its teaching force, Stanford University made him instructor in electrical engineering and shortly thereafter advanced him to the assistant professorship. He has been a member of the faculty since 1927. He also had done considerable research in lightning protection for several large oil companies towards protective measures for Pacific Coast tank farms.

Local Meetings

Future Section Meetings

Akron

Feb. 9—At 4:00 p.m. inspection trip through the Ohio Edison Company's East Akron substation. At 7:45 p.m. movies: "Through Oil Lands." At 8:15 p.m. James H. Foote, Allied Engineers, Inc., will speak on Load Shifting Transformers at Salt Springs. Meeting to be held in the auditorium of the Ohio Edison Co.

March 8—Electrical Refrigeration and Air Conditioning, by W. M. Timmerman, Gen. Elec. Refrigeration Co. Movies. Meeting to be held at Ohio Pwr. Co., Canton, preceded by dinner at Elks Club.

Baltimore

Feb. 19—Some Features of Interest in Motor Driven Water Pumping Stations, by Leon Small, water engr., City of Baltimore.

March 18—Subject to be announced. Speaker: Captain Greenlee, Director of Naval Experimental Station.

Chicago

Feb. 10—Modern Underground Cable Practise, by Herman Halperin, Commonwealth Edison Co.

March 17—Coordination of Insulation, by F. E. Andrews, Pub. Serv. Co. of Northern Illinois.

Cleveland

Feb. 18—Lightning—Recent Investigations and Findings, by K. B. McEachron, Gen. Elec. Co., Schenectady, N. Y.

March 24—Joint meeting with Case School of Applied Science Branch. Speaker: Dr. Dayton C. Miller.

Dallas

Feb. 26—Speaker: Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co.

March 21—Underground Construction and Cable Developments, by John Oram, Dallas Pwr. & Lt. Co. Meeting to be held in Fort Worth, Texas.

Detroit-Ann Arbor

Feb. 16—Fundamental Physical and Psychological Aspects of Television, by J. O. Perrine, Am. Tel. & Tel. Co. Demonstrations. Meeting to be held in the auditorium of the Michigan Bell Tel. Co.

March 15—Vacuum Tubes and Their Application, by E. H. Vedder, Westinghouse Elec. & Mfg. Co.

Lehigh Valley

Feb. 12—Airplane and Ship to Shore Communication, by Lloyd Espenschied, Am. Tel. & Tel. Co. Meeting to be held in Chamber of Commerce Bldg., Scranton.

March 18—Research—Industry's Health Insurance, by S. M. Kintner, Westinghouse Elec. & Mfg. Co.

Louisville

Feb. 19—Lightning—Recent Investigations and Findings, by F. W. Peek, Jr., Gen. Elec. Co.

March 18—Men Who Have Made Electrical Engineering History. Meeting under the auspices of students at Univ. of Louisville. Demonstrations.

Lynn

Feb. 17—Ladies' night.

Feb. 24—Mercury Vapor Steam Cycle, by Messrs. Sheldon and Coulsen.

March 9—Miracles in Nature, by Doctor Pillsbury.

New York

Power Group, Feb. 18—A-C. Low-Voltage Networks, by C. W. Pickells, New York & Queens Elec. Lt. & Pwr. Co.; A. Pinto, Otis Elevator Co.; L. A. Nettleton, Brooklyn Edison Co. Meeting to be held at 7:30 p.m. in the auditorium, Pub. Serv. Elec. and Gas Co., 80 Park Place, Newark, N.J. Nominations for officers of the Power Group for the year 1932-33 will be received at this meeting.

Pittsburgh

Feb. 9—New Developments in Mercury Arc Rectifiers. Speaker from Westinghouse Elec. & Mfg. Co.

March 8—Joint meeting with Association of Iron & Steel Elec. Engrs., and Engineers' Society of Western Penn.

Pittsfield

Feb. 16—Man-Made Islands to Speed Ocean Flying, by E. R. Armstrong.

March—Competitive meeting with Schenectady Section.

March 1—Famous Women Spies and Their Methods, by Major Coulson.

Seattle

Feb.—Communication Meeting. Speaker to be provided by the Am. Tel. & Tel. Co. Joint meeting with Inst. of Radio Engrs.

March—Annual joint meeting of founder societies.

Spokane

Feb. 26—Speaker: Dean H. V. Carpenter, State College of Washington and vice-pres. A.I.E.E.

March 25—Joint meeting with the Student Branches of the State College of Washington and University of Idaho. Papers by local members and students.

Vancouver

March 7—Students' night.

Past Section Meetings

Baltimore

Television—Its Physical, Fundamental, and Psychological Principles, by J. O. Perrine, Am. Tel. & Tel. Co. Demonstrations. Dinner meeting. Dec. 18. Att. 650.

Boston

Vertical Transportation, by A. S. Noyes, Otis Elevator Co. Illustrated. Films—"Virginia" and "Buried Sunshine." Dec. 8. Att. 65.

Cleveland

Behind the Scenes, by Zay Jeffries, Gen. Elec. Co. W. L. Enfield outlined developments in lamp construction. Inspection trip through the lamp development laboratory of the Gen. Elec. Co., moving pictures, and dinner. Dec. 17. Att. 173.

Dallas

Social meeting. Dec. 10. Att. 86.

Denver

Control of Commodity Prices, by M. F. Coolbaugh, Colorado School of Mines. Dinner. Dec. 18. Att. 20.

Precision Instruments, by A. W. Ainsworth, Wm. Ainsworth & Sons. Dinner. Nov. 20. Att. 53.

Erie

Electrons at Work and at Play, by Phillips Thomas, Westinghouse Elec. & Mfg. Co. Dec. 15. Att. 250.

Florida

Business meeting at which Prof. Melvin Price, chairman Florida State committee on engineers and employment organized by Amer. Engg. Council, spoke on the unemployment situation. Following this session the members

took part in the Conference on Student Activities of District No. 4, and gave attention and discussion to many papers presented by students. Prizes were awarded to the authors of the three best papers. The activities were concluded with a banquet at the Hotel Thomas. Dec. 4. Att. 41.

AIMS AND ACTIVITIES OF THE INSTITUTE AND ELECTRICAL INDUSTRY IN GENERAL, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Jan. 4. Att. 50.

Fort Wayne

A METHOD OF SYMMETRICAL COMPONENTS, by C. S. Allen, Gen. Elec. Co.; HEAVISIDE'S OPERATIONAL CALCULUS, by H. L. Boyer, Gen. Elec. Co. Dec. 17. Att. 32.

Houston

ARC WELDING IN BUILDING CONSTRUCTION, by P. N. Vinther, Dallas Pwr. & Lt. Co. Dinner. Dec. 16. Att. 40.

Indianapolis-Lafayette

SOME ASPECTS OF THE CONTROL OF PUBLIC UTILITIES, by Prof. L. M. Sears, Purdue Univ. Joint meeting with N.E.L.A. Dinner. Nov. 5. Att. 150.

RECENT DEVELOPMENTS IN THE ELECTRICAL FIELD, by C. W. Fick, Gen. Elec. Co. Illustrated. Dec. 18. Att. 50.

Iowa

PRESENT AND FUTURE OF THE ELECTRICAL INDUSTRY, by H. B. Hoffhaus, Des Moines Elec. Lt. Co.; TRANSMISSION FOR SALE, by C. L. Sampson, Northwestern Bell Tel. Co. Dinner. Dec. 16. Att. 16.

Kansas City

Social gathering. Dec. 22. Att. 65.

Los Angeles

THE GREAT AUSTRALIAN BUSH, by E. T. Bailey, pres. International Adventures. Illustrated. Dinner. Dec. 8. Att. 143.

Louisville

THE ENGINEERS PLACE IN THE SUN, by Prof. W. E. Freeman, Univ. of Kentucky and vice-pres. A.I.E.E. Dec. 18. Att. 65.

Lynn

THE STORY OF LIGHTNING, by K. B. McEachron, Gen. Elec. Co. Illustrated. Dec. 16. Att. 350.

MILADY GOES EXPLORING, by Mrs. Elizabeth Dickey. Dec. 2. Att. 1,200.

Madison

Joint meeting with the Univ. of Wisconsin Branch at which three papers on Faraday were presented by students. Dec. 10. Att. 53.

Memphis

TRACKLESS TROLLEYS, by A. D. McWhorter, Memphis St. Railway Co. Dec. 8. Att. 35.

Mexico

Annual banquet. Nov. 28. Att. 52.

Montana

ILLUMINATION, by C. S. Bossler, Curtis Lighting Co. Refreshments. Dec. 3. Att. 63.

New York

CONTROL OF VEHICULAR TRAFFIC, by R. E. Clisdell, Gen. Elec. Co., S. E. Kelley, Automatic Signal Engg. & Research Corp., and J. G. Hummel, Crouse Hinds Co. Jan. 6. Att. 200.

Niagara Frontier

DEION PRINCIPLE APPLIED TO LARGE CIRCUIT BREAKERS AND OTHER APPLICATIONS, by C. H. Sanford, Westinghouse Elec. & Mfg. Co. Dec. 18. Att. 85.

Oklahoma City

RECENT VIEWS ON ATOMIC STRUCTURE, by Homer L. Dodge, Univ. of Oklahoma. Moving pictures. Dec. 21. Att. 75.

Philadelphia

Social gathering. Dec. 14. Att. 250.

Pittsburgh

RECENT DEVELOPMENTS IN ELECTRICAL RESEARCH, by Philips Thomas, Westinghouse Elec. & Mfg. Co. Demonstrations. Joint meeting with Engineers' Soc. of Western Penn. Dec. 8. Att. 160.

Portland

THE STORY OF ALUMINUM, by C. R. Boyle, Aluminum Co. of America. Moving pictures. Nov. 17. Att. 80.

DETERMINATION OF ECONOMIC VOLTAGE AND CABLE SIZE FOR UNDERGROUND TRANSMISSION, by John Bankus, Gen. Elec. Co.; MECHANICAL STRENGTH OF WIRE HOLDERS AS DETERMINED BY TEST, by Corbett McLean and M. C. Parker, Northwestern Elec. Co.; LATEST TREND IN SUBWAY AND TRENCH LAY CABLE, by R. C. Schuknecht and T. W. Swartz, Northwestern Elec. Co.; A SPECIAL APPLICATION OF THE POTENTIOMETER, by J. L. Watson and R. Gleeson, Gen. Elec. Co. John Bankus awarded $25.00 Section prize for presentation of the best paper. Joint meeting with Oregon State College Branch. Dec. 8. Att. 74.

Providence

DEION AND DEION GRID OIL CIRCUIT BREAKERS, by Theodore Braaten, Westinghouse Elec. & Mfg. Co. Dinner. Oct. 13. Att. 40.

TROLLEY COACHES AND ELECTRICALLY OPERATED BUSES, by J. C. Thirlwall, Gen. Elec. Co. Dinner. Dec. 8. Att. 220.

St. Louis

THE OSAGE HYDROELECTRIC PROJECT, by R. R. Wisner, Union Elec. Lt. & Pwr. Co. Film—"Lake of the Ozarks". Dec. 16. Att. 290.

San Francisco

CALIFORNIA STATE WATER PROBLEM, by Lester S. Ready, consulting engr. Dec. 4. Att. 73.

Seattle

SYMPOSIUM ON RURAL ELECTRIFICATION, by H. J. Gille, Puget Sound Pwr. & Lt. Co., and L. J. Smith, Secy. State Committee on Relation of Electricity to Agriculture. Dinner. Dec. 15. Att. 66.

Sharon

TELEVISION—ITS PSYCHOLOGICAL EFFECTS, by J. O. Perrine, Am. Tel. & Tel. Co. Dec. 22. Att. 200.

Spokane

MANUFACTURE OF SAWDUST BRIQUETS, by R. T. Bowling, Potlatch Forests Inc. Dec. 16. Att. 25.

Syracuse

RADIO—THE GIANT NEW INDUSTRY, by J. D. Kelly, Westinghouse Elec. & Mfg. Co. Jan. 4. Att. 203.

Toledo

TELEVISION—ITS FUNDAMENTAL, PHYSICAL, AND PSYCHOLOGICAL PRINCIPLES, by J. O. Perrine, Am. Tel. & Tel. Co. Dec. 10. Att. 800.

Toronto

VIBRATION AND FATIGUE IN ELECTRICAL CONDUCTORS, by A. E. Davison, J. A. Ingles, and V. M. Martinoff, Hydroelectric Pwr. Comm. of Ontario. Dec. 11. Att. 100.

THE APPARENT FAILURE OF DEMOCRACY, by A. T. DeLury, University College. Joint meeting with Engg. Inst. of Canada. Jan. 8. Att. 250.

Utah

AIRWAY LIGHTING, by Alvin Priel, Dept. of Commerce. Nov. 9. Att. 38.

Elwood Bachman, Gen. Elec. Co., described the electrical installation at the Film Flom Mine of the Hudson Bay Mining and Smelting Co. Dinner. Dec. 14. Att. 32.

Vancouver

THE DESIGN OF THE MODERN RADIO RECEIVER, by V. W. M. Fouracre, Northern Elec. Co. Dec. 7. Att. 55.

Washington

INTERNATIONAL COMPARISON OF ELECTRICAL STANDARDS, by C. W. Vinal, and THE INTERNATIONAL ILLUMINATING CONGRESS OF 1931, by E. C. Crittenden, both of Bureau of Standards. Dinner. Dec. 8. Att. 75.

Worcester

ADVENTURES IN SCIENCE, by E. L. Manning, Gen. Elec. Co. Joint meeting with engineering societies in Worcester. Dec. 9. Att. 1,000.

Past Branch Meetings

University of Akron

THE PROGRESS OF RADIO, by John Chenot, student; REFRIGERATION, by R. Gerber, student. Dec. 9. Att. 15.

Alabama Polytechnic Institute

General discussion. Dec. 2. Att. 8.

MACHINES, by Prof. A. Thomas. T. N. Pyke, student, outlined his experiences at the Conference on Student Activities of District No. 4, held at the Univ. of Florida. Dec. 10. Att. 29.

University of Arkansas

RAILWAY SIGNALS, by F. S. Raedels, student; POTENTIOMETERS, by M. N. Shofner, student; USE OF LIBRARY AND TECHNICAL JOURNALS, by W. J. Pruett, student. Dec. 16. Att. 30.

STANDARDIZATION RULES, by H. L. Scott, student; STANDARDIZATION LABORATORY, by C. M. Huggler, student; ELECTRICAL STANDARDS, by P. H. Johnson, student. Jan. 6. Att. 32.

Case School of Applied Science

Lectures and demonstrations on lighting. Dec. 17. Att. 30.

Catholic University of America

TRANSATLANTIC CABLE LAYING, by Prof. T. J. McKavanagh, counselor. Illustrated. Dec. 9. Att. 38.

University of Cincinnati

OPERATING EXPERIENCE WITH LOW VOLTAGE A-C. NETWORKS, by L. L. Bosch, Columbia Engg. & Mgt. Corp. Dec. 9. Att. 40.

Clemson Agricultural College

A MOORING MAST ON WHEELS, by E. C. Parker, student. M. M. Smith, student, outlined current events in the electrical industry. Dec. 10. Att. 33.

THOMAS A. EDISON, by C. P. Walker, student. Moving pictures. Jan. 7. Att. 30.

Colorado State Agricultural College

ORGANIZATION OF DOHERTY CADET SYSTEM OF PUBLIC SERVICE CO. OF COLORADO, by Thomas Gray, Public Service Co. of Colo. Dec. 7. Att. 17.

APPLICATION OF ELECTRICAL HEAT IN ANNEALING, by John Kay, student. Dec. 14. Att. 18.

Cooper Union

THE WILKINS EXPEDITION TO POLAR REGIONS, by John A. Lundbeck, member of the electrical crew of the submarine "Nautilus." Dec. 11. Att. 65.

Cornell University

The Present Economic Situation, by Dean D. S. Kimball. Joint meeting with Ithaca Section. Dec. 11. Att. 52.

University of Detroit

Substation Operation, by Francis Moran, student; Radio Receiving Tubes, by Louis McNabb, student. Films—"Audion" and "That Little Big Fellow." Dec. 10. Att. 28.

University of Florida

Some Institute Problems, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Jan. 5. Att. 165.

Georgia School of Technology

Residence Lighting and Eye Conservation, by H. M. Horton, Gen. Elec. Co. Illustrated. Dec. 8. Att. 55.

Harvard University

History and Recent Development of the Kennelly-Heaviside Layer, by H. R. Mimno; Television, by J. H. Wright, student. Dec. 9. Att. 33.

University of Illinois

Film—"Blasting the Waterways of America." Dec. 9. Att. 25.

Transformer and Rectifier Connections, by Dean A. S. Langsdorf, Washington Univ. Dec. 17. Att. 160.

Iowa State College

Election of officers as follows: E. K. Rohr, chairman; M. D. Buttolph, vice-chairman; A. F. Zissler, secy.; F. G. Holdcroft, treas. Dec. 10. Att. 40.

University of Kansas

Klydonograph, by J. D. Swofford, student. Dec. 10. Att. 30.

Election of officers as follows: Wm. Kyte, chairman; Louis Farber, vice-chairman; Max Brauninger, secy.; Glen Wakely, treas. Moving pictures. Jan. 7. Att. 47.

University of Kentucky

Short Wave Transmission, by J. C. Starks, student. Dec. 17. Att. 39.

Lewis Institute

What Goes on in a Power House, by A. L. Peterson, Commonwealth Edison Co. Dec. 4. Att. 125.

University of Louisville

General discussion. Dec. 18. Att. 21.

Marquette University

The Electrical Profession, Development, and Organization of the A.I.E.E., by C. H. Krueger, chairman, Milwaukee Sec. Oct. 8. Att. 25.

Massachusetts Institute of Technology

Opportunities of the Young Electrical Engineering Graduate in a Large Manufacturing Company, by E. O. Shreve, Gen. Elec. Co. Dinner and smoker followed. Dec. 15. Att. 250.

University of Michigan

Commercial Aspects of a Public Utility, by A. D. McLay, Detroit Edison Co. Dec. 8. Att. 62.

School of Engineering of Milwaukee

The History of the A.I.E.E., by Taylor Decker and H. R. Spike, students. Film—"The Single Ridge." Dec. 10. Att. 37.

University of Minnesota

Inspection trip through the Pillsbury flour mills. Nov. 13. Att. 75.

Life of Faraday, by Edward Loye, student. Dec. 8. Att. 13.

Mississippi A. & M. College

The Life of Thomas A. Edison, by C. R. Lillybridge, student. Illustrated. Dec. 8. Att. 30.

Missouri School of Mines and Metallurgy

Prof. I. H. Lovett, counselor, and W. O. Woods, chairman, discussed electrification of railways. Rex Horn, student, described the uses of mercury arc rectifiers in electric railways. Dec. 9. Att. 11.

Montana State College

Ten papers presented by students. Dec. 3. Att. 119.

Illumination, by E. Bossler, Curtis Lighting Co. Joint meeting with Montana Section. Dec. 3. Att. 34.

Six papers presented by students. Dec. 10. Att. 114.

University of Nebraska

The Photoelectric Cell, by P. Jorgeson, student; The Potash Industry of Western Nebraska, by E. Knight, student. Dec. 9. Att. 16.

University of Nevada

Brushes and Commutation, by E. Zeigler, Westinghouse Elec. & Mfg. Co. Nov. 18. Att. 22.

Newark College of Engineering

Electrical Engineering Experiences in Brazil, by W. V. VanDyck, International Gen. Elec. Co. Dec. 16. Att. 35.

Life of Thomas A. Edison, by Prof. J. C. Peet, counselor. Jan. 4. Att. 14.

University of New Hampshire

Motion pictures. Nov. 28. Att. 31.

The Cold Cathode One-Hundred and Ten Volt Gaseous Illumina, by C. C. Dolloff, student. Dec. 5. Att. 30.

University of New Mexico

Smoker. Film—"Dynamic America." Dec. 9. Att. 35.

V. Brown, student, described his experiences while employed by the Westinghouse Elec. & Mfg. Co. Dec. 16. Att. 9.

College of the City of New York

Informal dance. Nov. 19. Att. 48.

The Life of Faraday and His Contributions to Science, by I. E. Lawlor, student; Faraday and Henry, by J. Raggazzini, student. Dec. 17. Att. 35.

New York University

Noise in Machinery, by H. C. Fleming, student; The Use of Photoelectric Cells in Photometry, by E. H. Osterland, student. Nov. 17. Att. 14.

Interurban Railway Transportation, by J. P. Monroe, student; Electron Tubes, by L. E. Dinnar, student. Dec. 1. Att. 15.

North Carolina State College

Banquet. Nov. 23. Att. 48.

Home Lighting, by J. C. McKinney, student; Prof. R. S. Fouraker, counselor, and G. E. Ritchie, chairman, gave reports of the activities at the Conference on Student Activities of District No. 4, held at the University of Florida. Dec. 8. Att. 28.

University of North Dakota

Relative to Relativity, by Prof. C. W. Byers. Dec. 9. Att. 26.

Northeastern University

Cables, Their Construction and Use, by E. W. Davis, Simplex Wire & Cable Co. Refreshments. Dec. 4. Att. 42.

Ohio University

Film—"Buried Sunshine." Jan. 6. Att. 36.

Oklahoma A. & M. College

Talks by several students. Nov. 23. Att. 25.

The Development, Theory, and Application of Watt-Hour Meters, by Harold Brown, student. Dec. 7. Att. 30.

Oregon State College

Joint meeting with the Portland Section. (See report under "Past Section Meetings.") Dec. 8. Att. 82.

Pennsylvania State College

Railway Signaling Devices and Their Application, by Mr. Rice; The Sonotone and Its Fundamental Construction, by Mr. Holt. Dec. 9. Att. 46.

Pratt Institute

Film—"The Story of an Electric Meter." Dec. 21. Att. 24.

Rensselaer Polytechnic Institute

A-C. Networks, by D. K. Blake, Gen. Elec. Co. Dec. 8. Att. 100.

Rhode Island State College

Film—"The Electric Ship." Dec. 3. Att. 30.

Action of the "Noden Valve" Rectifier, by M. J. Carr, student; The Common "Tungar" Rectifier, by Joseph Strauss and George Freedman, students. Dec. 10. Att. 18.

Inspection trips through the Industrial Trust Building and the Narragansett Elec. Lt. Co., followed by a lecture on Television, by J. O. Perrine, Am. Tel. & Tel. Co. Dec. 15. Att. 18.

Mercury Arc Rectifiers, by J. F. Schmidt, student. Dec. 17. Att. 10.

Rice Institute

Discussion. Jan. 6. Att. 11.

Rose Polytechnic Institute

Thomas A. Edison, by Wayne Plimmer, student. Dec. 9. Att. 38.

University of Santa Clara

Film—"Thomas A. Edison." Joint meeting with A.S.M.E. Dec. 10. Att. 89.

University of South Carolina

Election of officers as follows: A. R. Urquhart, chairman; H. G. Smith, vice-chairman; E. C. Salley, secy.-treas. Dec. 10. Att. 31.

South Dakota State School of Mines

General discussion. Dec. 3. Att. 30.

University of Southern California

Ship to Shore Communication, by Paul Johnson, Pacific Tel. & Tel. Co. Dec. 2. Att. 26.

Applications of Thyratron Tubes, by Berdett Ives, Gen. Elec. Co. Dec. 9. Att. 23.

Southern Methodist University

Life Works of Thomas A. Edison, by A. Fellrath, student. Illustrated. Joint meeting with A.S.M.E. Branch. Oct. 9. Att. 32.

Stanford University

Inspection trip through Pacific Gas & Elec. Co. Station A. Oct. 24. Att. 22.

Photo-Telegraphy Equipment, by W. Noel Eldred, student. Dec. 3. Att. 21.

Inspection trip through an exchange of Pacific Tel. & Tel. Co., San Francisco. Dec. 4. Att. 23.

Stevens Institute of Technology

Talk by Col. C. O. Gunther on the Reserve Officers Training Corps. Dec. 11. Att. 38.

Inspection trip through the U.S.S. Akron and U.S.S. Los Angeles. Nov. 27. Att. 30.

University of Tennessee

The Life of Thomas A. Edison, by C. J. Bryn, student. Illustrated. Nov. 25. Att. 65.

Texas A. & M. College

General discussion of Branch activities. Dec. 7. Att. 20.

Business meeting. Jan. 7. Att. 25.

Texas Technological College

Talks by Prof. L. S. Grandy and Dean Wm. J. Miller on the activities of the A.I.E.E. Film—"Magic of Communications." Nov. 23. Att. 27.

University of Texas

H. P. Woods, student, described a new proposed method of solving constants of the Fourier series by means of electromechanical mechanisms. Oct. 22. Att. 12.

University of Utah

Sunlight Lamps, by W. Ottenstein, student; Mercury Arc Lamps, by E. I. Christensen, student. Dec. 3. Att. 27.

You, by H. T. Plumb, Gen. Elec. Co. Dec. 10. Att. 55.

University of Vermont

Radio Interference, by Mr. Logan, student. Nov. 23. Att. 18.

Film—"The Single Ridge." Dec. 7. Att. 33.

Virginia Military Institute

Electrical Refrigeration, by R. J. Meybin, student; "DeForest—The Man Who Made Radio Broadcasting Possible," by J. Roberts, student; An Automatic Diesel Electric Plant, by H. J. Pence, student; The Radio Telephone, by T. J. Moore, student. Dec. 5. Att. 55.

WABC's New Wireless Antenna, by R. P. Sledge, student; Sound Pictures, by C. E. Schoonover, student; The Niagara Power Development, by S. J. Stone, student; A Power Plant That Flies, by G. B. Hightower, student; The Restoration of the Beauty of Niagara, by S. J. Mergenhagen, student. Dec. 22. Att. 54.

The Communication System of the Waldorf-Astoria, by W. L. Kelly, student; The Effects of Electric Shock, by C. S. Betts, student; Neon Electric Signs, by C. A. Payne, student; The Work of the Army Air Corps, by W. P. DeSaussure, student. Jan. 4. Att. 57.

Virginia Polytechnic Institute

Reports of the Conference on Student Activities of District No. 4, held at the Univ. of Florida were given by those who attended that meeting. Dec. 10. Att. 36.

State College of Washington

Films—"Industrious Diamonds," "The Telephone," and "Voice Highways." Dec. 4. Att. 37.

Washington University

Operation of the St. Louis Municipal Police Radio Broadcasting System, by Louis Siech, student. Dec. 11. Att. 17.

University of Wyoming

Film—"The Single Ridge." Nov. 20. Att. 21.

The Development of the Microphone, by F. Wickenkamp, student; Electrical Aids to Blind Flying, by T. R. Hance, student. Dec. 1. Att. 6.

Yale University

Acoustics, by S. K. Wolfe. Dec. 8. Att. 44.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

Construction

E.E., 33, 10 yr. practical experience in elect. construction work on new buildings. Familiar with all branches of elect. contracting including estimating, field engg. and purchasing. Has had complete charge of electrical work in various large building projects in New York City. A-850.

ASSOC. E.E., 34, married, technical education, desires position with utility. Exceptional ability in underground transmission and distribution systems. One yr. central station construction experience. Location, immaterial. Available on short notice. D-278.

Design and Development

E.E. and M.E. grad., 37. 13 yr. comprehensive experience with nationally known firms in designing, drafting, and engineering of modern power plants and substations. Engg. reports and specifications for diesel-electric plants. Inspection and experimental work. Foreign languages. Work and location immaterial. Available immediately. C-8195.

E.E., M.E. DESIGN ENGR. College trained, wide experience development and design; mech. and elec. apparatus; special machinery; thorough knowledge manufacturing; 5 patents. Desires connection where inventive ability and persevering effort to obtain desired results efficiently and economically are essential. Excellent references. N.Y. metropolitan district preferred. B-8219.

PWR. PLANT ENGR. 15 yr. exp. in drafting, design, and construction; elec. and mech., including complete mill and pwr. plant steam generating equipment. English schooling and technical training. American citizen, single. Also some operating and maintenance experience. B-9747.

E.E., grad. 32, married. 8 yr. exp. elec. and mech. design of small motors and fans. Capable of full responsibility for development of a-c. and d-c. motors, generators, and allied products. Up to the minute on capacitor motor design. Middlewest preferred. C-5353.

M.E. and E.E., FORMER CORNELL INSTRUCTOR in machine design for 4 yr., Allis-Chalmers designers and checker 5 yr., served shop apprenticeship, 32, single. Desires teaching or engg. opportunity. Salary open. D-122.

GRAD. E. E., single, 29, Westinghouse engg. and design school graduate course. Five yr. transformer design experience. Desires position with utility, engg. or mfg. concern. D-209.

Draftsmen

ELEC. DRAFTSMAN, 44, married, 5 yr. experience switchboard, supervisory control wiring diagrams, plant and substation layout. 2,300-volt and 220-kv. distribution system. Available at once. Location, anywhere. D-209.

E. E. GRAD., 1928, single, 27. Experienced in design drafting, estimating and layout of substations, switchboards, wiring diagrams, lighting, conduit, transmission and distribution lines. Desires connection in elec. field. Location, immaterial. D-89.

Executives

GRAD. ELEC., HYDRO-ELEC. ENGR., 31, married. 2 yr. exp. marine elec. installation. 7 yr. exp. design, construction of steam and hydro pwr. plants, outdoor and indoor substations, transm. and distr. lines, wiring diag., indus. plants, office blds., estimating, preparation of specifications. Desires position where experience counts. Available short notice. Middle Atlantic States preferred. D-212.

ENGG. EXEC., 33, married. Elec. grad., 10 yr. exp. in mgmt., design and constr. with leading utility company and mfgr. Desires position with utility company, mfgr., or consultant where initiative, aggressiveness, and judiciousness will show in results of work. South or West preferred. Available immediately. C-4734.

EXEC., SALES, PURCHASING or as asst. to engr. Grad. engr., 20 yr. exp. in maintenance, contracting, purchasing, and design and layout of mech. and elec. eqpt. of indust. and pwr. plants. Location, N.Y. metropolitan district. B-5050.

E.E. GRAD. Married. 15 yr. with electrification, distribution, generation, substations, motor applications and controls, lighting, etc. as applied to utilities, coal mining, cement mills, elec. furnaces, automotive industries. Experience covers estimates, design, layouts, constr. and maintenance. Utility, mining, or indus. concern desired. C-5277.

EXEC. ASST. to pres. or v.-pres. of holding company or large operating utility. 24 yr. exp. in all phases of operation, production, transmission, distribution, utilization, engineering, and construction of utilities and industrials; also rates and valuations, elec., gas and water systems. D-208.

E.E. Wide indus. background in exec. capacities: elec. and mech. engg., steel industry; devpt. engg., mining industries; comml. and pwr. sales engg., utility field; technical editor in publishing field; versed in economics and mgmt. and able to cooperate with personnel. Available immediately. Location immaterial. B-4905.

E.E., GRAD. 14 yr. exp. with utilities and engg. firms covering engg., design, and valuation of pwr. plants, substations and transm. lines. Desires position with utility or engg. firm where organizing and exec., as well as engg. ability is required. Available immediately. C-9570.

ENGG. EXECUTIVE, 33, E.E. and M.E. Grad., ten yr. experience in mgmt., design, construction, production, accounting, and sales, with steel mill, mfr., and utility desires position as chief engr., works mgr., or other executive capacity where a calm, judicial disposition coupled with initiative and aggressiveness will show up in results. C-1297.

E.E. Grad., 48, married. Twenty-six yr. experience as designing, report, power and executive engineer with 3 engg. and construction firms, including system planning, design, construction cost estimating and construction supervision of power plants, substations and transmission facilities for utilities and industrials, Studies of operating economics. B-4553.

E.E. Grad. R.P.I., 34, married. Five yr. with large mfr. of elec. control equipment. Five yr. with prominent engg. firm as elec. designer on power plant and industrial work. Familiar with physical layout, elec. equipment, and wiring for central stations and industrial plants. B-6274.

E. E. GRAD., 1910, experience principally in power and light elect. engg., desires position offering similar or elec. ry. experience. Eastern ocation preferred. B-1923.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.	205 West Wacker Drive	31 West 39th St.
San Francisco	Chicago	New York
N. D. Cook, Manager	L. E. Griffith, Manager	W. V. Brown, Manager

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

E. E., 30, 8 yr. broad utility experience, desires new association. Executive ability, ambitious and seriously seeking opportunity where progress can be expected in exchange for effort. Background of practical and administrative detail in power distribution plants. Keenly interested in rural electrification, coordinated commercial technical problems. Middlewest preferred, not essential. C-9959.

EXECUTIVE ENGR., 54, widower, gen. mgr., small utility. Asst. mgr., dist. mgr. of larger organization. Over 20 yr. executive experience in operation of small town utilities. Also qualified as valuation and rate engr. Available immediately. Location preferred, U.S.A. or Canada. B-7932-321-C-1-San Francisco.

Financial

FINANCIAL ENGR., Cornell (M.E.-E.E.). Twelve yr. regulatory commission; 4 with utility holding mgmt. corp.; 8 months intensive course bond buying department leading insurance company; employed almost 4 yr. thereafter on financial and fact finding investigations by outstanding consulting engg. organization. Desires opportunity New York City. Salary open. C-2953.

Instruction

UNIV. OF WASHINGTON GRAD., E.E., 2 yr. with Bell Tel. Lab., 5 yr. teaching elec. and mech. engg., and 2 yr. testing and experimental work with bus and truck manufacturer. Desires position with automobile or truck manufacturer, or teaching automotive engg. Available at once. B-7830.

E.E. Grad., 21, single, B.S., 1931, Worcester Polytechnic Inst. desires connection with industry, or with teaching; also interested in drafting. Location, immaterial. Available upon short notice. D-228.

E. E. GRAD., member Tau Beta Pi, Assoc. A.I.E.E., degrees B.S., will teach mathematics, power plant design, or structural design. B-5551.

Maintenance and Operation

E.E., 32, married, 12 yr. experience in the construction, maintenance and operation of power house auxiliaries, high voltage switching equipment. Substations, switchboard erection and wiring, control wiring and relay applications. Location, immaterial. Available at once. D-273.

E.E. Grad. 33 years, wide experience in operation and maintenance of both steam and hydro power plants and system operation. Also well educated in modern business and 5 yr. experience in accounting. Excellent references. Will accept position anywhere in U.S. C-7796.

E.E., 29, married. Westinghouse and Western Electric training. Five yr. maintenance and construction, 2 yr. power plant construction and 2 yr. detailing and layout. Desires position with mfg., engg. utility or ry. concern. Location, immaterial. Available on short notice. D-257.

CONSTRUCTION AND MAINTENANCE SUPT., E.E. Grad., 37, married. Thirteen yr. experience in the utility field, particularly in engg., construction and maintenance of distribution and transmission substations. Desires position wish large utility with responsibility for the construction, operation and maintenance of substations. B-2885.

Research

1931 E.E. GRAD., 23, single. Desires position with any mfg., utility, concern, or in any elec. engg. field. Prefers position in design and research, or the application and use of vacuum tubes. Willing to start at the bottom. Locaion, immaterial. Available immediately. D-221.

M.I.T. GRAD. E.E., 35, married. Six yr. industrial and teaching experience in e.e. Several years private research and development work on own initiative. Good ability, integrity, and personality. Desires position for life work. Location preferred, Middlewest or South. C-2826.

PHYSICIST, 32, married, 12 yr. experience in laboratories, large elec. mfrs., desires development engg. with small company. Experience mostly with vacuum or gas discharge devices, good theoretical knowledge of high frequency currents (Harvard graduate); physical chemistry, particularly thermodynamics, theoretical mechanics, and probability theory. B-8390.

Sales

COMMERCIAL MGR., 49, married. Grad. E.E. Fifteen yr. elec. pwr. companies in charge of sale of industrial power and equipment. Handled domestic sales. Trained salesmen. Large results. Previous 8 yr. handled men high tension hydroelectric construction and operation. Will consider any location. D-250-3112-C-2-San Francisco.

E. E., Cornell Unv. 1925, G.E. test course and 4 yr. sales engr. with Gen. Elec. Co. Desires position with industrial concern, consulting engg. firm or utility. Southern location preferred but interested in any locality where there is opportunity. Available on short notice. C-7135.

DISTRICT SALES MGR. OR MFR'S AGENT. Experienced engg. representative, desires connection with high grade company that has line of industrial or utility equipment. East preferred. B-4067.

E.E. GRAD., married, 39, wide sales experience with utility and industrial companies on electrical supplies, merchandise, and equipment. Desires position requiring good personality and ability to meet executives as well as a thorough knowledge of selling and of merchandising. B-1196.

Testing

1930 E.E., Drexel Inst., 24, single, 1½ yr. experience in making complete electrical tests on distribution, power and rectifier transformers, and metering equipment. Also G.E. test floor experience. Desires position with utility or industrial concern. Available at once. Location, immaterial. C-9913.

Junior Engineers

1931 GRAD. E.E., of 5 yr. co-op. school, 23, single. Experience includes machine shop, telephone central office trouble shooting, and large municipal fire alarm system. Desires position with mfr. or utility. Willing to start at bottom. Middlewest preferred; elsewhere satisfactory. C-9825.

1931 E.E. GRAD., Midwestern college, 24, single. One yr. student engr. on G.E. test. References furnished. Available on 2 wk. notice. C-9497.

GRAD. E.E., 1929, single, 23. Fifteen months as student engr. on G.E. test. Some test, drafting, and switchboard construction experience before graduation. Interested in position with concern doing consulting or construction work or with utility or mfr. Available at once. Location anywhere in U.S. C-8028.

1931 GRAD. E.E., single, 22, American. Desires position in the elect. industry with an opportunity for advancement. Chicago resident, location preferred, Middlewest. Available immediately. C-9909.

1931 E.E. Grad., 24, single. Experience in maintenance and installation of power plant equipment, also knowledge of photoelectric cells and pub. address systems. Available immediately. D-289.

1931 E.E. Grad., 24, American, single, Univ. of Virginia, desires position in elect. industry, preferably radio or one of its affiliated branches. Experience in protective relay systems with utility. Has kept up with radio industry since 1920. Salary secondary. Location, U.S. or foreign. D-290.

JUNIOR ENGR., 26, single. Desires connection with utility, sound picture industry or radio mfg. firm. G.E. test course, utility distribution test experience. Test, design, construction, maintenance and engg. work in radio receiver mfg. plant. Location, immaterial. C-8596.

1931 E.E. GRAD., Midwest univ., 23, single. Three months' experience with large utility, 3 months with elect. contacting and construction company. Desires utility work, especially interested in power plants, transmission, distribution, agricultural development. Location, immaterial. D-282.

GRAD. E.E., 27, married, 5 yr. experience with Gen. Elec. Co., including test course, induction motor design, application engg., and district office sales work. Also experience in automotive electrical work. Available on short notice. C-9236.

E. E. GRAD., 22, single. Experienced in power transformer repairing, overhead and underground systems maintenance for pub. utility. Some experience in electric refrigeration and ice cream manufacturing. Specialized in transmission in college. Will consider any job within reason. Location, anywhere. Available at once. C-9418.

E. E., Pratt 1931. Experience in vacuum tubes, resistors, technical and general office work. Desires employment in radio, television, or sound work. Location, New York. Available immediately. C-5636.

1931 E. E. GRAD., Lehigh Univ., 22, single. Summer experience with utility. Interested in position with utility or industrial concern. Eastern states preferred, but other locations considered. Available at once. D-301.

1931 GRAD. E. E., 23, single. B.S. degree from Montana State College. Special courses taken in utility work. Excellent scholastic record. Location, immaterial, foreign western or otherwise. Experience desirable. Available immediately. D-303.

Membership

Recommended for Transfer

The board of examiners, at its meetings on the dates indicated below recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow (Jan. 20, 1932)

Foote, James H., supervising elec. engr., Commonwealth & Southern Corp., Jackson, Mich.
Kloeffler, Royce G., prof. of elec. engg. and head of dept., Kansas State Col., Manhattan.

To Grade of Member (Dec. 22, 1931)

Cornelius, Clinton C., supt., overhead systems engg. dept., Kansas City Pwr. & Lt. Co., Kansas City, Mo.
Fitz, Ernest S., mgr., prod. & trans., Virginia Elec. & Pwr. Co., Richmond, Va.
Hall, Raymond A., district plant engr., Pacific Tel. & Tel. Co., San Francisco, Calif.
Hollister, Vernon L., consulting engr., prof. elec. engg., Univ. of Nebraska, Lincoln.
Hotopp, Alfred H., Jr., divn. engr., Wired Radio, Inc., Ampere, N.J.
Kalantar, H. Hamaz, elec. engr., New York, N.Y.
Loud, Francis M., engr., Jackson & Moreland, New York, N.Y.
Maxwell, John F., head of distribution divn. E.E. dept., Edison Elec. Illum. Co., Boston, Mass.
McCarty, Roy A., mgr., pwr. engg. dept., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Mowdawalla, Framroze N., exec. engr., Hydro Elec. Dept., Chepauk, Madras, India
Newton, Edward T., patent examiner, U.S. Pat. Off., Washington, D.C.
Peek, Joseph W., elec. engr., Cleveland Elec. Illum. Co., Cleveland, O.
Wolff, Samuel S., chf. engr., American Elec. Motor Co., Cedarbury, Wis.

To Grade of Member (Jan. 20, 1932)

Doremus, Francis H., sales engr., Gen. Elec. Co. Denver, Colo.
Ewart, James B., chief engr., The Teleregister Corp., New York
Graff, Murray G., sales engr., Gen. Elec. Co., Denver, Colo.
Halloran, Delavan, asst. engr., N.Y. & Queens Elec. Lt. & Pwr. Co., Flushing, N.Y.
Harte, Charles R., engr., The Connecticut Co., New Haven, Conn.
Kidd, Walter J., design engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Knutz, Wm. H., engr. of elec. design, Midland United Co., Chicago, Ill.
Lindberg, Wm. A., engr. of circuit design and service investigation, Commonwealth Edison Co., Chicago, Ill.
Stock, Robert J., elec. engr., dept. of pub. utilities, Cincinnati, Ohio

Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the secretary before February 29, 1932.

Abrahamson, C.O., Square D Co., Phila., Pa.
Adams, R.O., Dayton Pwr. & Lt. Co., Ohio

Alger,B.A.,N.J.Bell Tel.Co.,Newark
Allan,F.S.,Bell Tel.Labs.,N.Y.City
Allison,A.R.,Col.City of Detroit,Mich.
Anderson,G.S.,Pac. Military Academy, Culver City,Calif.
Andres,R.R.,Bell Tel.Labs.,N.Y.City
Arnold,S.,San Jose State Teachers Col.,Calif.
Ashton,C.H.,Eberle Tanning Co.,Westfield,Pa.
Asmann,J.W.,Union Gas & Elec.Co.,Cincinnati, Ohio
Asmus,W.F.,57 E.101st Place,Chicago,Ill.
Bahr,P.A.,Gen'l Elec.Co.,Schenectady,N.Y.
Bailey,C.A.,Gen'l Elec.Co.,Schenectady,N.Y.
Bailey,F.W.,U.S.Govt.Cust.House,St.Louis,Mo.
Baird,H.S.,Shortwave & Television Corp.,Boston,Mass.
Ballinger,M.H.,Indiana Gen'l Serv.Co.,Marion
Banks,J.O.,U.S.WarDept.,Ft.Sam Houston,Tex.
Benard,F.E.,Oficina de Investigaciones Geofisicas,Mexico,D.F.
Bigsby,O.S.,R.D.No.3,Syracuse,N.Y.
Billow,W.K.,Pub.Serv.Co.of Colorado,Denver
Blahna,C.,United Air Cleaner Corp.,Chicago,Ill.
Blomquist,S.A.,R.F.D.No.2,Sandy,Utah
Boyles,A.W.,Gen'l Elec.Co.,Schenectady,N.Y.
Braunsdorff,A.H.,Kaelberer Elec.Co.,Mattoon, Ill.
Brown,C.B.,First National Television,Inc.,Kansas City,Kans.
Brown,F.A.,State College,Bozeman,Montana
Burke,W.J.,Gen'l Elec.Co.,Erie,Pa.
Burns,J.A.,Sarvas Elec.Co.,New York,N.Y.
Bush,A.E.,Detroit Edison Co.,Mich.
Butterfield,W.L.,N.Y.& Queens Elec.Lt.& Pwr. Co.,Flushing,N.Y.
Cabrera,I.,P.O.Box 166,Angola,Ind.
Cady,C.I.,(Member),Voorhees Gmelin &Walker, N.Y.City
Castiglia,F.H.,R.F.D.No.11,Westport,Conn.
Charbonneau, A.P.,Cutler-Hammer, Inc.,Milwaukee,Wis.
Chen,S.,Mass.Inst.of Tech.,Cambridge,Mass.
Clark,G.G.,Ohio Bell Tel.Co.,Akron,Ohio
Clark,R.L.,U.S. Dept. of Commerce,Detroit, Mich.
Clayson,G.S.,William Ainsworth & Sons,Denver,Colo.
Clayton,W.F.,Ford Motor Co.,Dearborn,Mich.
Clema,J.M.,Westinghouse Elec.& Mfg.Co.,East Pittsburgh,Pa.
Comer,J.S.,Gibbs & Hill,Inc.,N.Y.City
Coughlan,J.B.,249 E.6th St.,Tracy,Calif.
Cox,W.J.,Gen'l Elec.X-Ray Corp.,Memphis, Tenn.
Crawford,W.T.,Phila.Elec.Co.,Pa.
Darrow,D.O.,State College,Corvallis,Ore.
Davidson,M.,Mountain States Tel.& Tel.Co., Helena,Montana
Davies,J.E.,Pub.Serv.Co.of Colo.,Idaho Springs
Decker,A.H.,Wisconsin Pwr.& Lt.Co.,Fond du Lac,Wis.
Defina, F.P.,Hazleton,Pa.
DeTraglia,G.J.,1601 Bleecker St.,Utica,N.Y.
Dixon,E.D.,Oklahoma Gas & Elec.Co.,Enid
Donnelly,J.W.,Cons.Gas Elec.Lt.& Pwr.Co., Baltimore,Md.
Double,C.R.,U.S.Bur.of Recl.,Denver,Colo.
Dowis,W.J.,Hudson Coal Co.,Scranton,Pa.
Downs,S.G.,Hartford Stm.Boiler Insp.& Ins. Co.,Pittsburgh,Pa.
Entrekin,H.R.,Western Elec.Co.,Chicago,Ill.
Ewald,E.,Minneapolis Gen'l Elec.Co.,Minn.
Fenwick,J.O.,Duncan Elec.Mfg.Co.,Lafayette, Ind.
Fiedler,G.J.,Univ.of Kansas,Lawrence
Fischer,F.K.,Westinghouse Elec.& Mfg.Co.,East Pittsburgh,Pa.
Fiske,J.H.,2218 Union St.,Berkeley,Calif.
Foote,A.G.,Gen'l Elec.Co.,Cleveland,Ohio
Fuhlbrugge,H.F.,N.W.Public Service Co.,Yankton,So.Dak.
Fulkerson,W.H.,Jerseyville,Ill.
Galbraith,R.E.,Allis Chalmers Mfg.Co.,West Allis,Wis.
Garrahan,C.J.,Moore School of Elec.Engg., Phila.,Pa.
Gavitt,H.T.,N.Y.Telephone Co.,N.Y.City
Geehr,F.F.,1327 Washington St.,Easton,Pa.
Gillis,N.S.,141 Hamilton St.,Rochester,N.Y.
Gioberti,P.A.,311 Ave.A.,N.Y.City
Goelzer,C.A.,N.Y.& Queens Elec. Lt.& Pwr.Co., Flushing,N.Y.
Goodwin,J.S.,1105 No.Holliston Ave.,Pasadena, Calif.
Gosbee,W.S.,Western Canada Pwr.Co.,Stave Falls,B.C.,Can.
Graham,J.H.,Westinghouse Elec.& Mfg.Co., Wilkinsburg,Pa.
Graves,C.J.,49 Park Blvd.,Lancaster,N.Y.
Gray,G.E.,Sears Roebuck & Co.,Chicago,Ill.
Greco,C.S.,191 Washington St.,New Britain, Conn.
Greene,L.G.,821 South Main St.,East Greenwich,R.I.
Griffiths,J.,Jr.,Warner Bros.Theater Corp.,Ansonia,Conn.
Hadwin,T.F.,Westinghouse Elec.& Mfg.Co., East Pittsburgh,Pa.
Hagan,E.J.,Bell Tel.Co.of Penna.,Phila.,Pa.
Hall,G.B.,Bell Tel.Labs.,New York,N.Y.
Happel,J.H.,South Penn Power Co.,Waynesboro,Pa.
Hasenkamp,J.F.,Lawson Elec.Co.,Chattanooga, Tenn.
Hay,E.C., Canadian Westinghouse Co., Ltd., Hamilton,Ont.,Can.
Heller,G.,Columbia Univ.,N.Y.City
Heltzel,W.E.,Am.Tel.& Tel.Co.,Evansvills,Ind.
Henderson,A.B.,N.Y.& Queens Elec.Lt.& Pwr. Co.,Flushing,N.Y.
Hendrixson,L.H.,Central Ave.,Chino,Calif.
Hilmer,M.,R.D.No.1,Perkasie,Pa.
Hobbs,C.F.,Northwood,No.Dak.
Hoddy,J.S.,1892 Suffolk Rd.,Columbus,Ohio
Hoisington,L.R.,706 Polk St.,San Francisco,Cal.
Holmes,R.A.,Indiana Bell Tel.Co.,South Bend, Indiana
Hoover,V.A.,Calif.Inst.of Tech.,Pasadena;Univ. of Calif.,Los Angeles,Calif.
Hornby,F.B.,Gen'l Elec.Co.,Lynn,Mass.
Humphrey,R.G.,4040 Monroe St.,Chicago,Ill.
Hunter,J.C.,United Elec.Lt.& Pr.Co.,N.Y.City
Isaacs,E.K.,City of Boston,Transit Dept.,Boston,Mass.
Jefferson,W.O.,City of Gainesville,Fla.
Jenkins,A.C.,Calif.State R.R.Comm.,San Francisco
Jernigan,C.H.,Univ.of Florida,Gainesville
Johansen,H.C.,Commonwealth Edison Co.,Chicago,Ill.
Johnson,R.R.,1617 Yale Ave.,Apt.506,Seattle, Wash.
Jones,W.C.,B.F.Sturtevant Co.,Hyde Park, Mass.
Jury,J.E.,Ind.Prod.Sales Corp.,Pine Lawn,Mo.
Keener,C.E.,Drexel Inst.,Phila.,Pa.
Kelly,R.E.,445 Reed Ave.,Monessen,Pa.
Kennedy,F.K.,616 Main St.,Peckville,Pa.
Kettler,C.J.,Gen'l Elec.Co.,Schenectady,N.Y.
Kirkland,W.N.,Gen'l Elec. Co.,Schenectady, N.Y.
Knabe,T.A.,Pilkinton,Va.
Knoll,A.F.,Champion Coated Paper Co.,Hamilton,Ohio
Kohn,G.H.,Gen'l Elec.Co.,Phila.,Pa.
Kreindler,M.A.,Union Gas & Elec.Co.,Cincinnati,Ohio
Lamkey,F.R.,Gen'l Elec.Co.,Schenectady,N.Y.
Landry,S.A.,Roessler & Hasslacher Chemical Co.,Niagara Falls,N.Y.
LaPierre,W.A.,N.Y.& Queens Elec.Lt.& Pr.Co., Flushing,N.Y.
Laudenslager,R.L.,Brooklyn (N.Y.) Edison Co.,
Lawrence,W.T.,Automatic Elec.Co.,Chicago,Ill.
Lawson,B.P.,Vega Labs.Corp.,New Rochelle, N.Y.
Leatherman,H.A.,Westinghouse Elec.& Mfg. Co.,Mansfield,Ohio
Ledvina,J.P.,Penn.Water & Power Co.,Holtwood,Pa.
Lemberg,F.B.,Brooklyn Edison Co.,Brooklyn, N.Y.
Lewis,G.R.,Brooklyn Edison Co.,Brooklyn,N.Y.
Leonard,S.C.,Gen'l Elec.Co.,Schenectady,N.Y.
Lethert,C.W.,Minneapolis General Electric Co., Minn.
Lingle,R.G.,Am.Tel.& Tel.Co.,Allentown,Pa.
Lockner,J.F.,Los Angeles Gas & Elec.Corp., Seal Beach,Calif.
Loney,F.M.,324 East St.,Springfield,Ohio
Loukomsky,S.A.,Gen'l Elec.Co.,West Lynn, Mass.
Ludwig,H.F.,The Montana Pwr.Co.,Great Falls, Mont.
Macaulay,W.R.,Hartford Elec.Lt.Co.,Hartford, Conn.
MacLaughlin,R.B.,Brooklyn Edison Co.,Inc., Brooklyn,N.Y.
Mann,H.H.,United Elec. Lt. & Pwr. Co.,New York,N.Y.
Mattheiss,W.H.,Bell Tel.Labs.,N.Y.City
McConnell,R.C.,10418 Johanna Ave.,Roscoe, Calif.
McNeil,R.S.,Gen'l Elec.Co.,Bridgeport,Conn.
Meece,F.H.,Carolina Pr.& Lt.Co.,Fayetteville, N.C.
Meier,H.H.,123 No.7thAve.,Highland Park,N.J.
Milde,E.C.,Westinghouse Elec.& Mfg.Co.,East Springfield,Mass.
Miller,C.J.,Jr.,Univ.of Calif.,Berkeley,Calif.
Miller,C.W.,N.Y.& Queens Elec.Lt.& Pr.Co., Flushing,N.Y.
Munier,R.F.,Wagner Elec.Corp.,St.Louis,Mo.
Naab,M.P.,Wisconsin Telephone Co.,Milwaukee,Wis.
Nadeau,J.I.,Western Elec.Co.,Chicago,Ill.
Nebel,J.A.,Chicago Normal Col.,Ill.
Newman,M.K.,Westinghouse Elec.& Mfg.Co., East Pittsburgh,Pa.
Nickerson,A.F.,63 Grove St.,North Attleboro, Mass.
O'Connor,J.V.,Brooklyn Edison Co.,Brooklyn, N.Y.
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February 1932

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Winter convention papers which are abstracted in this issue

Number	Author	Title
☐ 32-29	H. V. Putman	Surge-Proof Transformers
☐ 32-47	C. M. Hathaway and R. C. Buell	An Automatic Oscillograph
☐ 32-48	I. H. Summers	Vector Theory of Circuits Involving Synchronous Machines
☐ 32-49	K. K. Palueff and J. H. Hagenguth	Effect of Transient Voltages on Power Transformer Design—IV
☐ 32-50	A. L. Atherton	High Capacity Rectifier Efficiency Improved by Sectionalizing
☐ 32-51	E. W. Brown	Time and Its Measurement
☐ 32-52	A. L. Loomis and W. A. Marrison	Modern Developments in Precision Clocks
☐ 32-53	W. C. Hahn and C. F. Wagner	Standard Decrement Curves
☐ 32M4	C. F. Wagner and S. H. Wright	Calculation of Short Circuits on Power Systems
☐ 32M5	W. C. Hahn	Decrement Curves for Specific Systems
☐ ——	M. H. Woodward and A. F. Connery	Direct Printing Over Long Non-Loaded Submarine Telegraph Cables

Papers presented prior to September 1931 and upon which articles in this issue are based

Number	Author	Title
☐ 31-92	C. H. Sanderson and E. B. Ricketts	Automatic Combustion Control
☐ 31-101	D. D. Higgins and E. Wild	Reestablishing Excitation of a Loaded Alternator in Parallel with Others
☐ 31-112	H. W. Dodge and C. H. Willis	A Corona Tube Voltage Regulator

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Engineering Literature

New Books

In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during December are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

HANDBOOK OF INDUSTRIAL ELECTRICITY. By M. Kushlan. N. Y., McGraw-Hill Bk. Co., 1931. 535 p., 7x5 in., lea., $4.——A non-technical reference book for those engaged in electrical construction, maintenance, testing, inspection and contracting. It covers wiring for light, power, telephones, and signals in buildings of all kinds and for outdoor installations. Estimating is discussed.

LES MACHINES A COURANTS CONTINUS. By R. Langlois-Berthelot, with a preface by M. Paul Janet. Paris, Gauthier-Villars et Cie, 1931. 289 p., 10x7 in., paper, 75 Fr.——An elementary treatise on continuous-current machines discussing the principles, characteristics, and uses of dynamos and motors from a modern point of view, well fitted to prepare the reader for the study of a-c. machinery.

PERSONNEL MANAGEMENT. By W. D. Scott, R. C. Clothier and S. B. Mathewson. 2nd ed. N. Y., McGraw-Hill Bk. Co., 1931. 583 p., 9x6 in., cloth, $4.——A comprehensive outline of the principles of personnel management as they are understood and applied today, both to the management of individuals and of groups; summarizes experience of many employers; useful both as a text and for reference.

QUEST FOR POWER. By H. P. Vowles and M. W. Vowles. London, Chapman & Hall, Ltd., 1931. 354 p., 9x6 in., cloth, 15s.——The aim of the authors is to present a systematic, connected survey of modern progress in power engineering, displayed in proper perspective against a historical background and suitable for the general reader. This object has been accomplished with unusual success.

POLYPHASE INDUCTION MOTORS. By L. Lagron, trans. fm. French by R. C. Simpson and M. G. Say. London & Glasgow, Blackie & Son, Ltd., 1931. 218 p., 9x6 in., cloth, 15s.——The theory, design and use of the polyphase induction motor and its simpler variants are clearly and concisely described. The complete design of a 45-hp. low-voltage motor is worked out for both slip-ring and cage rotors. A chapter is devoted to testing, and another to power-factor correction and speed control.

YOUR HEALTH—AND YOUR EARNING POWER. N. Y., N.E.L.A., 1931. 181 p., 9x5 in., cloth, $0.65.——This book, prepared for distribution to employees of industrial concerns, is an instructive, non-technical handbook on the care of the body in health and disease. Diet, living habits, personal hygiene, disease prevention, first aid in illness, home nursing and first aid in accidents are discussed in simple, practical fashion.

ALTERNATING - CURRENT BRIDGE METHODS. By B. Hague. 2 ed., Lond. & N. Y., Isaac Pitman & Sons, 1931. 391 p., 9x6 in., cloth, $4.50.——Provides a fairly complete account of the theory and practical working of these methods, useful to post-graduate workers and those engaged in original research or accurate testing. Field is restricted to frequencies not exceeding those used in telephonic research. New edition, revised. Numerous references to original sources.

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A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

BALANCING OF MACHINERY. By C. N. Fletcher. Lond., Emmott & Co., 1931. 172 p., 9x6 in., cloth, 10s 6d.——Balancing of high-speed machinery is discussed from the point of view of the production engineer. The book summarizes the factors that affect balance, describes the better known apparatus for detecting unbalance, and the methods and calculations involved in correcting. Treatment is entirely practical.

COMMUNICATION. By D. O. Woodbury. N. Y., Dodd, Mead & Co., 1931. 280 p., 8x6 in., cloth, $2.50.——A popular account of the evolution of communication by telegraph, telephone, radio, and mail.

INCREDIBLE CARNEGIE, the Life of Andrew Carnegie (1835-1919). By J. K. Winkler. N. Y., Vanguard Press, 1931. 307 p., 9x6 in., cloth, $3.50.——Carnegie's spectacular rise from poverty to great wealth is told in interesting, journalistic fashion in this biography.

INDUSTRIAL HYGIENE for Engineers and Managers. By C. P. McCord, assisted by F. P. Allen. N. Y. & Lond., Harper & Brothers, 1931. 336 p., 10x6 in., cloth, $5.——A handbook on all phases of the preservation of life in industry, in which the latest methods of disease and accident prevention are discussed from the points of view of the physician and the executive.

INTERNATIONALER STROMAUSTAUSCH. By K. Dohrn. Munster i. Westf., Helios-Verlag, 1931. 69 p., 10x6 in., paper, 3.75 RM.——International electrical power networks being formed in Europe and America give rise to important economic and political questions, which are discussed in this pamphlet. The evolution and present condition of international interconnections in Switzerland, Austria, Scandinavia, Germany and Canada are discussed, and the policies adopted are studied.

RADIO TELEGRAPHY AND TELEPHONY. By R. L. Duncan and C. E. Drew. 2 ed. revised and enlarged, N. Y., J. Wiley & Sons; Lond., Chapman & Hall, Ltd. 1931, 1,046 p., 9x6 in., cloth, $7.50.——A comprehensive work, intended for use as a text-book by students and as a practical handbook by operators. The authors have aimed to cover the entire field, from the principles involved to the present complex application of them, in a simple, non-mathematical way.

WIRELESS. By L. B. Turner. Cambridge (England), University Press; New York, Macmillan Co. 1931. 528 p., 9x6 in., cloth, $8.50.——This book aims to present an account of radio theory and practise within the field of telegraphy and telephony which will be readable by a competent electrical engineer who has not studied high-frequency phenomena. The work will be useful to serious students who have passed the elementary stage.

Selected Items From Current Literature

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 2,000 technical periodicals are given in the following columns. All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page, or make translations of foreign articles at cost.

AIRCRAFT

Electric Equipment. Applications of Electricity in Aircraft, H.A.Campbell. *Aviation Eng.*, v 5, Nov '31, p 13-17. Table gives maximum length to which circuits may be expected to be run; electrical calculations for twin-engined flying boat; wiring diagrams; generators and regulators; battery performance.

A Power Plant that Flies, R.E.Hudson. *Elec. Jl.*, 28, Nov '31, p 605-9. Electrical system designed to combine 100 per cent dependability with extraordinarily light weight.

ARMATURES

Checking Winding Data with Slide Rule, W.O.Hurlbut. *Maintenance Eng.*, v 89, Oct '31, p 503-4. Outline of method of checking winding data with slide rule with special marks on upper stationary scale.

BUSBARS

Generator Lead Tunnel Satisfies Many Demands. *Elec. World*, v 98, Nov 21, '31, p 906-7. At Ariel hydroelectric development of Inland Power and Light Co., 13,800-volt leads, which tie 56, 250-kva. generator directly to step-up transformers with only disconnecting switches circuit, are carried through concrete tunnel under transformer platform; layout is shown in some detail.

CABLES

Use of Buried Cable for Underground Construction, W.R.Bullard. *Elec. World*, v 98, Dec 12, '31, p 1054-7. Suggests extension of use of buried cable to effect construction economies; operating advantages and disadvantages of buried cable.

Operation. Cable Operation—'30. *N.E.L.A.—Comm. Rept.* no. 161, Oct '31, 29 p. Rate of failures on high voltage underground systems continued in '30, downward trend in evidence since '26.

Research. Cable Research. *N.E.L.A.—Comm. Rept.* no. 160, Oct '31, 6 p. Research projects conducted under direction of cable research subcommittee since its organization, *i.e.*, effect of temperature on rate of deterioration of impregnated cable paper; study of ionization in paper-insulated high-voltage cables; influence of residual air and moisture in impregnated paper insulation. Bibliography.

Testing. Acceptance Inspection and Testing of Cable. *N.E.L.A.—Comm. Rept.* no. 162, Oct '31, 12 p. Marked discrepancy encountered at times between measured resistance of conductor and its area has been found to be entirely due to errors in one or more of various measurements. Bibliography.

COMMUTATOR BRUSHES

Brush Efficiency, A.A.A.Rodrigues. *Maintenance Eng.*, v 89, Oct '31, p 495. Practical discussion of proper methods of obtaining high brush efficiency through proper operation and maintenance.

CONDUCTERS

Installation. Raceway Simplified Installation of Converter Leads, S.Watkins. *Elec. World*, v 98, Nov. '31, p 966. Economy in installing runs of heavy leads between supply transformers and two 300- and 500-kva. new rotary converters was solved in industrial plant.

CONVERTERS

Revamping Old Converters Improves Operation, R. H. Newton. *Power*, v 74, Dec. 8, '31, p 831. Edison Elec. Illum. Co. of Boston revamping 5 of its 2,250-kw., 60-cycle booster converters; design and constructional features.

CONVEYORS

On and Off Up and Down Automatically, R.G.Lockett. *Maintenance Eng.*, v 89, Oct '31, p 491-4. Design, construction and operating details of automatic vertical conveyor; electric control features.

Electric Drive. Individual Drives Operate Cotton Gin Economically, W.D.Sinclair. *Elec. World*, v 98, Nov 21, '31, p 908-9. Features of drives in 10-unit cotton gin; new gin will turn out cotton on shipping platform at figure of 13 kw-hr. per bale; typical installations; specifications of motor drives.

ELECTRIC FURNACES

Annealing. Strip and Sheet Annealing in Electric Furnace with Atmosphere Control, W.S.Scott. *Iron Age*, v 128, Dec 3, '31, p 1422-5 & 32. Design and operation of furnaces for bright annealing developed by Westinghouse E. & M. Co.; savings between $1.50 and $3.50 a ton. (To be concluded.)

Carburizing. Electric Carburizing Saves Labor of Eighteen Men, E.F.Davis. *Elec. World*, v 98, Nov 7, '31, p 827-8. By substituting mechanical furnace where elements of time and temperature are under sensitive control and making such a furnace as automatic as practical, two men with two 90-kw. electric furnaces are producing equivalent output to 20 men by old box furnace practise.

High Temperatures. Methods of High Temperature Treatment, P.P.Cioffi. *Franklin Inst.—Jl.*, v 212, Nov '31, p 601-12. Direct heating of wire and tape specimens in gases; inductive heating of toroidal specimens; sketch illustrates glass furnace, steel furnace, and Gaede 4-stage mercury diffusion pump.

ELECTRONS

Classical Electrodynamics and Conservation of Energy, W.F.G.Swann. *Franklin Inst.—Jl.*, v 212, Nov '31, p 563-76. Theoretical mathematical analysis.

ENGINEERS

Engineering. Engineer's Growing Civic Responsibilities, F.L.Stuart. *A.S.C.E.—Trans.*, v 95, '31, p 1294-1302. Presidential address at annual convention at Tacoma, Wash., July 8, '31.

Engineers' Opportunities, F.L.Stuart. *Civil Eng. (N.Y.)*, v 1, Dec '31, p 1337-9. Present economic depression is result of insufficient production in years following war; longer working hours and increased output will constitute essential step in progress toward prosperity.

Future Will Demand More Economics in Engineering, W.S.Monroe. *Elec. World*, v 98, Nov 21, '31, p 904-6. From practical point of view, economics of engineering become largely matter of recognizing importance that fixed charges on investment bear to ultimate value of enterprise; also economics need more engineering; central-station industry has little idle capital in over-built plants; no fear of necessity for rapid write-off of modern stations.

New Competition and New Horizons in Engineering, F.H.McDonald. *Civil Eng. (N.Y.)*, v 1, Dec '31, p 1361-3. Undeveloped fields and modern demands of profession; recent changes in engineering and business which give new outlooks; social responsibility; problems of using goods.

Earnings. '30 Earnings of Mechanical Engineers—III. *Mech. Eng.*, v 53, Dec '31, p 876-82. Clippings from chart book of A.S.M.E. committee; earnings in principal industries; earnings and type of work.

Employment. Keeping Engineer Employed, H.M.Friend. *Power*, v 74, Dec 8, '31, p 835-6. What some large corporations are doing to maintain their engineering forces intact; wage cuts have been equitable.

Liability. Designer of Failed Coal Pocket Guilty of Manslaughter. *Eng. News-Rec.*, v 107, Dec 3, '31, p 899 & 902; editorial p 871. Collapse of New York coal pocket, which caused death of 3 men and injury of 11 others, resulted in conviction of designer by jury for second degree manslaughter.

GALVANOMETERS

Portable String Galvanometer for Use at Moderate Frequencies, E.W.Marchant, J.K. Burkitt and A.H.Langley. *Sci. Instruments—Jl.*, v 8, July '31, p 209-14. Frequency of vibration of 150-200 per sec.; to secure critical damping, string is arranged in oil-filled case; to maintain proportionality between deflection and current, string is supported at ends by springs. (To be continued.)

GENERATORS

Parallel Operation of A-C. Generators—II, E.H.Stivender. *Pwr. Plant Eng.*, v 35, Dec 1, '31, p 1147-8. Consideration of use of current-limiting reactors, as related to parallel operation.

HEAT TREATMENT

Steel Strip and Sheet Annealing in Electric Furnace with Atmosphere Control. *N.E.L.A.—Comm. Rept.* no. 22, Nov '31, 13 p. Report supplements N.E.L.A. Publication No. 141.

IRON AND STEEL PLANTS

Electric Frequency. Follansbee, W.Va. Plant of Follansbee Brothers Company Changes from 25 Cycles to 60 Cycles, J.S.Murray. *Iron & Steel Engr.*, v 8, Nov '31, p 453-66. Old and new plants analyzed; change-over discussed in detail; total demand averaged 3,800 kva.; plant was 100 per cent in operation at time of change.

Electric Power. Steel Mill Electrification Reduces Production Costs. *Elec. World*, v 98, Nov 14, '31, p 878-9. Lowered costs result from increased production, difference between purchased power and steam expenses, reduction of unit electricity rate due to increased utilization as result of electrification; Carpenter Steel Co., Reading, Pa.

LIGHT AND LIGHTING

This Ultraviolet Situation, M.Luckiesh. *Elec. World*, v 98, Nov 7, '31, p 829-32. Curative values of less importance than preventive ones; summary of evidence argues for artificial sunlight; combination of health radiation and illumination advocated.

Size of Object, Visibility and Vision, C.E. Ferree and G.Rand. *Illum. Eng. Soc.—Trans.*, v 26, Oct '31, p 820-56. Effect of changes in size of object on speed of discrimination is studied for different intensities of illumination and different relations of object to background.

AIRPORT

U.S. Aerodrome Lighting, K.W.Mackall. *Aircraft Eng.*, v 3, Nov '31, p 285-90. Characteristics of various types of lights in current use.

INDUSTRIAL

Automatic Control of Industrial Lighting, E.H.Vedder and S.G.Hibben. *Mill and Factory Illust.* v 9, Oct '31, p 36-7. Survey of advantages of automatic control; circuit diagram of typical photo-cell automatic unit shows standard Mazda lamp used for pilot.

Visual Efficiency. Light and the Human Machine, M.Luckiesh. *Elec. World*, v 98, Dec 5, '31, p 1001-2. Eyes of subjects were tested at beginning and again at close of day's work; results compared and tabulated.

LINES

Losses. Determining Tie Line Losses, H.Estrada and H.A.Dryar. *Elec. World*, v 98, Oct 24, '31, p 745-50. Tie line losses may have considerable effect on economical load allocation and decisions for interchange of energy; method of applying increment losses to these problems; other applications of increment loss are enumerated.

Rural. Characteristics of Rural Electric Lines, C.P.Wagner. *Agric. Eng.*, v 12, Nov '31, p 413-15. Presents detailed statistical analysis of territory under discussion.

LOUD SPEAKERS

Use of Rochelle Salt Crystals for Electrical Reproducers and Microphones, C.B.Sawyer. *Inst. Radio Engrs.—Proc.*, v 19, Nov '31, p 2020-9. Methods developed permit cheap commercial production of Rochelle salt crystals; microphones, pick-ups, and especially speakers are described.

MOTORS

Protection. Thermal Cutouts for Protecting A-C. Motors, H.D.Braley. *Power*, v 74, Nov 17, '31, p 703-5. Thermal cutouts for overload protection compared with protective devices that provide short-circuit protection; characteristics of devices for properly protecting motors against overloads, and types of thermal cutouts.

Windings. Winding Calculation Reduced to Single Slide-Rule Setting, W.O.Hurlbut. *Elec. West*, v 67, Nov 1, '31, p 228-9. Method of securing motor winding layout permits easy, rapid calculation of turn per phase and wire size for any given frame size.

NETWORKS

Design. System Plan Alternatives Visualized for Executives, M.M.Samuels. *Elec. World*, v 98, Oct 31, '31, p 778-82. Expansion forecasting affected by current uncertainties; load prognostication on population basis safer than on customer total; significance of each plan can be condensed to tabular form for executive action; sample form used by author for analyzing plan.

Fluctuation. Starting Currents on Networks, L.C.Bell. *Elec. Jl.*, v 28, Nov '31, p 615-7. Duquesne Light Co. has tested low tension network to determine how much current can be drawn without causing noticeable flicker in lights.

Losses. System Losses—Their Analysis and Reduction, M.M.Koch. *Elec. World*, v 98, Nov 28, '31, p 948-51. Procedure to be followed in analyzing losses; methods of reducing them; samples of balance sheets and form used for detailed analysis of losses.

OSCILLOGRAPHS

Cathode-Ray Oscillograph Timing Axis, F.T. Brewer. *Electronics*, v 3, Dec '31, p 222-3. Principles of performance of sweeping circuit; circuit diagrams and characteristics.

PHOTOELECTRIC CELLS

A New Selenium Tube, G.F.Metcalf and A.J. King. *Electronics*, v 3, Dec '31, p 234-5. Characteristics of new FJ-31 cell manufactured by Gen. Elec. Co.; data on typical circuits. Bibliography.

Applications. Electronic Control of Machinery, R.F.Yates. *Iron Age*, v 128, Nov 19, '31, p 1299-1300 & 1349. Production gages, in which movement of anvils is amplified electrically by vacuum tube; grid-glow tube used in new stroboscope.

PHOTOMETERS

Automatic Recording Photoelectric Cell Distribution Photometer, W.F.Little and H.J. Eckweiler. *Illum. Eng. Soc.—Trans.*, v 26,

Oct '31, p 810-19. Efforts made to develop recording photometer which accurately integrates flicker from rotating luminaire and which completes, in time short enough to be practicable, continuous-curve record giving complete average candlepower data in surface of sphere.

POLES, WOODEN

Making of Holding Tests of Guy Anchors. *Telephony*, v 101, Nov 21, '31, p 33-4. Method of making field tests of various types of anchors; photographs show set-up for experiments and also types of failure encountered.

POTENTIOMETERS

Simple Method for Measurements of Residual Inductance on Potentiometers and Four-Terminal Resistance Coils, N.F.Astbury. *Sci. Instruments—Jl.*, v 8, July '31, p 221-3. Simple bridge method is described for measurement of inductances of potentiometers and four-terminal resistances.

POWER PLANTS

Diesel-Electric. Diesel Stand-By Power in Hydro-Electric Plant, E.Swan. *Power*, v 74, Nov 17, '31, p 708-9. Design and operating characteristics of Central Power Company's Diesel Plant at Kearney, Nebraska; list of equipment.

Hydroelectric. Ice As Affecting Power Plants. *A.S.C.E.—Trans.*, v 95, '31, p 1134-5. Final report of committee of power division; surface formations; bottom formations. Bibliography.

Ice Prevention at Racks of Hydraulic Plants. *Pwr. Plant Eng.*, v 35, Nov 15, '31, p 1109-10. Description of two installations of electrically heated racks, also of open-channel and other mechanical methods.

Beauharnois Harnesses St. Lawrence for 2,000,000 Hp. *Elec. World*, v 98, Nov 14, '31, p 860-5. Provision also made for deep waterway; electrically driven machinery used for excavation; detailed illustration of operating gallery between wheel and generator levels.

Safe Harbor Development Adopts Kaplan Turbines. *Elec. World*, v 98, Dec 5, '31, p 992-6. Features of Holtwood plant of Pennsylvania Water & Power Co., and Conowingo plant of Susquehanna Power Co.

Steam-Electric. Operating Features of Station A, (San Francisco) C.E.Steinbeck. *Power*, v 74, Nov 17, '31, p 697-702. Summary providing background for detailed operating procedure; diagrams of piping.

POWER SUPPLY

Current Theft. Current Theft and Its Prevention, S.A.Fletcher. *Elec. World*, v 98, Nov 21, '31, p 924-6. Notes on extent of practise; various methods of connecting meter boxes providing means of prevention.

Rural. Declares Rural Lines Cost Too Much, J.H.Matthews. *Elec. World*, v 98, Nov 28, '31, p 952-3. Author finds no reason for present farm line costs or quality; contends adequate low cost construction should be standardized.

RADIO

Amplifiers. Audio-frequency compensation methods, J.G.Aceves. *Electronics*, v 3, Dec '31, p 224-5. Methods of compensation of losses in radio-frequency end of radio receivers in audio system; notes on reinforcement of high audio-frequencies and frequency band suppression; use of circuit as scratch filter for phonograph reproduction.

Antennas. Radiation Resistance of Complex Antennas, K.Tani. *Nat. Research Council Japan—Reports*, v 1, Aug '31, p 185-97. Theoretical mathematical analysis. (In English.)

Detectors. Grid Circuit Linear Detection, J.R.Nelson. *Radio Eng.*, v 11, Nov '31, p 32-4. If same results as are obtained with present detectors could be obtained by less radio-frequency voltage, cheaper radio-frequency amplifier could be used.

Engineering. Second Meeting of the International Technical Consulting Committee on Radio Communication, Copenhagen, '31. *Inst. Radio Engrs.—Proc.*, v 19, Dec '31, p 2219-49. 21 opinions which were unanimously approved at the '31 C.C.I.R. meeting are given together with 14 questions for consideration at third meeting to be held in Lisbon, Portugal; list of members of U.S. delegation.

Frequency. Notes on Generation of Absolute Frequencies, T.Kujirai and S.Fujitaka. *Nat. Research Council Japan—Reports*, v 1, Aug '31, p 199-201. Authors tried to eliminate intermediate standard tuning fork; generated required frequencies directly from oscillation of pendulum made of single steel rod, with period of about 1.093 sec., kept swinging with constant amplitude. (In English.)

Interference. Methods for Measuring Interfering Noises, L.Espenschied. *Inst. Radio Engrs.—Proc.*, v 19, Nov '31, p 1951-4. Various methods of measuring interference which have been found useful in Bell System.

Measuring Instruments. A direct Reading Modulation Meter, A.H.Cooper and G.P.Smith. *Wireless Engr. and Experimental Wireless*, v 8, Dec '31, p 647. Instrument does not require calibration from oscillograph or other apparatus; wiring diagram is given.

Modulators. Amplitude, Phase, and Frequency Modulation, H.Roder. *Inst. Radio Engrs.—Proc.*, v 19, Dec '31, p 2145-76. Comparative theoretical study of amplitude, phase, and frequency modulation. Bibliography.

Oscillators. Constant Frequency Oscillators, F.B.Llewellyn. *Inst. Radio Engrs.—Proc.*, v 19, Dec '31, p 2063-94. Manner in which frequency of vacuum tube oscillators depends upon operating voltages; theory of dependence deprived; experimental data showing degree of frequency stability which may be expected as result of application of methods outlined in theory.

A New Treatment of Electron Tube Oscillators With Feed-Back Coupling, C.K.Jen. *Inst. Radio Engrs.—Proc.*, v 19, Dec '31, p 2109-44. Theoretical mathematical analysis.

A Recent Development in Vacuum Tube Oscillator Circuits, J.B.Dow. *Inst. Radio Engrs.—Proc.*, v 19, Dec '31, p 2095-2108. Constant frequency oscillator of two-anode type (UX-865) is described.

Adjustment of Multivibrator for Frequency Division, V.J.Andrew. *Inst. Radio Engrs.—Proc.*, v 19, Nov '31, p 1911-17. In multivibrator controlled by voltage of another frequency bearing harmonic relationship to multivibrator frequency, effect of varying control voltage is analyzed; method for determining best value of this voltage.

Neon Tube Audio-Frequency Oscillator, D. Pollack. *Radio Eng.*, v 11, Nov '31, p 24-5. Surface details and characteristics of oscillators which may be used in any position where sinusoidal waveform is not essential.

Vacuum Tubes as High-Frequency Oscillators, E.D.McArthur and E.E.Spitzer. *Inst. Radio Engrs.—Proc.*, v 19, Nov '31, p 1971-82. Problem of tubes for generating power at wavelengths below five meters is discussed; essential data are given for examples of each type of tube. Bibliography.

Research. Recording Characteristics of Radio Signals and Static, S.R.Winters. *Radio Engr.*, v 11, Nov '31, p 36-8. Three-in-one instrument, developed by radio laboratory of Bureau of Standards, measures strength of broadcasting stations, denotes fading of radio signals, and records static; 100-acre laboratory for radio transmission research is established near Fairfax, Va.; description of equipment and circuit diagrams.

Telephone. Radio Telephony by Ultra Short Waves, S.Uda. *Nat. Research Council Japan—Reports*, v 1, Aug '31, p 203-5. In previous experiments with decimeter waves, transmitter and receiver were different in construction, so that, for two-way communication, separate transmitter and receiver were needed; equipment much improved and single set now used both for transmitter and receiver.

Transmission. Some Observations of Behavior of Earth Currents and Their Correlation with Magnetic Disturbances and Radio Transmission, I.S.Bemis. *Inst. Radio Engrs.—Proc.*, v 19, Nov '31, p 1931-47. Radio transmission data collected on telephone circuits operating between New York and London and between New York and Buenos Aires; earth current data collected on two Bell System lines extending 100 mi. north and west from New York.

New Methods of Frequency Control Employing Long Lines, J.W.Conklin, J.L.Finch and C.W.Hansell. *Inst. Radio Engrs.—Proc.*, v 19, Nov '31, p 1918-30. Practical difficulties encountered in commercial operation of short-wave transmitters summarized; methods for meeting these objections through frequency control by long radio-frequency transmission lines.

Transmitters. Frequency Stabilization of Radio Transmitters, Y.Kusunose and S. Ishikawa. *Nat. Research Council Japan—Reports*, v 1, Aug '31, p 157-83. Experimental research with regard to frequency stabilization by means of constant-frequency oscillator; quartz-stabilized oscillator; mechanically-stabilized oscillator; valve-stabilized oscillator. (In English.)

Waves. Polarization of High-Frequency Waves and Their Direction Finding, S.Namba, E.Iso and S.Ueno. *Inst. Radio Engrs.—Proc.*, v 19, Nov '31, p 2000-19. Results of experiments which were conducted during past two years for purpose of studying high-frequency transmission phenomena, and some physical explanations deduced therefrom.

RAILROADS

A.E.R.A. Reports. Electrical Section Reports. *A.R.E.A.—Bul.*, v 33, Aug '31, 84 p. Synopsis of reports of electrical section.

Lackawanna Electrification. A series of articles dealing with "major features," "new features," "power supply and distribution," "mercury arc rectifiers," "catenary system," "signals and interlocking system," "substations," "testing," etc., occupying practically the entire issue of the Gen. Elec. Rev., v 34, Nov '31, p 597 ff.

Train Control. Electronic Equipment in Train Control. *Electronics*, v 3, Dec '31, p 218-20. Reliability of vacuum tubes in industrial applications is shown by their practical use in railway signal control systems.

RELAYS

Photoelectric. Light-Sensitive Relays Now on the Market. *Electronics*, v 3, Nov '31, p 194-5. Discussion covers Westinghouse, General Electric, Allen-Bradley, and Burgess equipment now available commercially.

Protective. Automatic Live Line Selection, C.W.Jones. *Elec. World*, v 98, Nov 14, '31, p 876. Scheme developed to select live line under conditions where substation is tapped off two transmission lines through motor-operated air-break switches; wiring diagram.

SUBSTATIONS

Outdoor Substation Design. *N.E.L.A.—Comm. Rept.* no. 164, Nov '31, 43 p. Notes covering details of substation structures, materials, equipment, and protection.

TELEPHONE

Industry. Present Day Economics of Telephony, R.A.Lumpkin. *Telephony*, v 101, Nov 28, '31, p 14-16. Effects of "depression proof" industry idea in public mind; possibilities and problems of future as shown by results of efforts in past year; newly understood policies outlined.

Measurements. Attenuation Measurements on Telephone and Telegraph Lines, J.W.Horton. *Radio Eng.*, v 11, Nov '31, p 25-6. Apparatus and connections for measuring line attenuation by modification of standard method.

Relays. Characteristics of Strowger Relays, K.W.Graybill. *Telephone Engr.*, v 35, Nov '31, p 30-1 & 49. Characteristics of various special types of relays; graphs showing details of their operation.

TELEVISION

New Television System, R.W.Tanner. *Radio Eng.*, v 11, Nov '31, p 27-8. System described has possibilities in throwing received picture directly upon screen, without employing lens; new type of mercury arc tube is used for illumination.

VACUUM TUBES

New Electron Tubes—Facts and Rumors. *Electronics*, v 3, Dec '31, p 216-7. Editorial announcing new short-wave tube for television, *i.e.*, Triple-Twin tube of Cable Laboratories, combining detector and power stage in same envelope; r.f. pentodes with preliminary rating and characteristics.

Cathode Ray. Improvements in Cathode-Ray Tube Design, V.K.Zworykin. *Electronics*, v 3, Nov '31, p 188-90. Tube developed is of hot-cathode, high-vacuum type; focusing done electrostatically; special features afford many new applications of oscillograph, including use as television receiver.

Cold. A "Cold" Filamentless Radio Tube, C.W.Hough. *Electronics*, v 3, Nov '41, p 182-3. Tube developed by A.Hund of Ampere, N.J., operates as amplifier, modulator, detector, oscillator; note on cold tube invented in Germany, by G.Seibt.

Pentode. Pentode Tubes Used as Triodes, J.R.Nelson. *Electronics*, v 3, Dec '31, p 226-7 & 254. Curves show pentode characteristics of 247-type, output current and harmonic content of power pentode, effect of by-passing self-bias resistance of push-pull pentodes, and power output and distortion of pentodes in parallel; features of tube used as triode.

Screen-Grid. Choosing a Screen-Grid Tube, R.DeCola. *Radio Eng.*, v 11, Dec '31, p 15-16, & 32. Experimental inquiry with reference to characteristics of '235, '551 and '224-type radio tubes.

Transmitting. Design and Development of High-Power Oscillator or Amplifier Tube UV-862, R.W.Larsen. *Radio Eng.*, v 11, Dec '31, p 18-22 & 30. Technical account of development of UV-862 transmitter electron tube; table of characteristics and construction details of tube.

Voltmeters. Vacuum Tube Theory and Practice. *Telephone Engr.*, v 35, Nov '31, p 23-4 & 36. New type of instrument known as rectifier-type voltmeter; used to measure voltage of any frequency from one to 30,000 cycles with fair accuracy; theory and use of rectifier type voltmeter in telephone plant testing work.

WELDING

Control of Spot and Flash Welds, G.A. Hughes. *Welding Engr.*, v 16, July '31, p 33-6. Summary of tests on resistance butt welded joints; Lehigh University welding symposiums; comparative Brinell and Rockwell hardness tests made on resistance welds in low carbon steel.

Houses, Steel-Frame. Residences of Welded Steel Construction. *Eng. News-Rec.*, v 107, Nov 26, '31, p 839-40. Symposium consisting of 2 papers; comparative cost estimate of steel and wood-frame construction.

Coal Mines. Electric Arc Welding in Mines, C.Lee. *Elec. World*, v 98, Nov 28, '31, p 953-4. Economy of welding in coal-mine practise with various types of equipment; curves showing cost of resistance welding *vs.* motor-generator set.

X-Ray Analysis. Guaranteed by X-Ray Inspection, W.H.Shipman. *Am. Mach.*, v 75, Nov 5, '31, p 708-9. X-ray inspecting and testing methods at Barberton plant of Babcock and Wilcox Co; cost of continuous use will not be more than $5 per hr. ordinarily.

Industrial Notes

Construction Volume in 1931.—In reviewing construction activities in the final quarter of 1931, as well as in the year itself, the F. W. Dodge Corporation finds that the 1931 total for all types of construction in the thirty-seven states east of the Rockies amounted to $3,092,849,500 in actual contracts awarded in that area. The year's final quarter produced a contract total of $530,141,700 for all classes of construction in these thirty-seven states. Of this total for the last three months of the year, 34 per cent represents construction of public works and utilities, which amounted to $180,178,200. This compares with 32 per cent of the whole in the final quarter of 1930.

New Southern Agent For Corning Glass.—The Corning Glass Works, Corning, N. Y., has announced the appointment of the W. L. Rose Equipment Company, in St. Louis, Mo., as agents for the sale of PYREX power insulators in the southern part of Illinois and eastern part of Missouri, and Arkansas, and the western part of Tennessee.

New Speed Recorder.—An operation and speed recorder has been developed by the Amthor Testing Instrument Company, Inc., 309 Johnson Street, Brooklyn, N. Y., which automatically produces a detailed record of the speeds and operation of any rotating machine during the entire day. It shows all starting and stopping periods, the revolutions per minute, fluctuations, etc., recorded directly from the action of the machine itself. A few of the more common applications are on turbines for recording operating speeds and the correctness of the over-speed or safety trip, and on engines and motors.

New Pole-Top Switches.—The Delta-Star Electric Company, Chicago, announces a new line of two and three-pole, gang operated pole-top switches for distribution line voltages up to 34.5 kv. The tilting insulator carries a hinged loop and as the switch opens this loop travels along, keeping the stranded conductor from dropping down, eliminating the usual hinged links. The insulator pins, levers and fittings are of malleable iron, the channel base of steel. All parts, bolts and nuts at line potential are of non-ferrous metal. Solderless clamp connector terminals are provided for connection to the line conductors.

New Contact Alloys.—Pitting of electrical contacts is said to be practically eliminated with the new contact alloys developed by P. R. Mallory & Company, Indianapolis, Indiana. These alloys possess marked advantages over ordinary contact materials. The specific applications are as follows: Alloy known as 3W3 is recommended for oil circuit breakers as well as interrupter contacts for resistance seam welders operating in air. Another, known as 20S, is suitable for arcing tips of very high current density. Still another, G11, is used for arcing tips of low current density and also for make and break contacts where current density is high and non-welding necessary. G13 is used for make and break contacts where current density is high and welding of contacts is not encountered.

Allen-Bradley Exhibition of Motor Control.—The most extensive exhibit of motor control equipment ever brought together in Chicago by a single manufacturer will take place during the four weeks beginning February 1st, when the Allen-Bradley Company, of Milwaukee, will display units representing their entire line of motor controllers and accessories. The fifth floor of the Engineering Building, at 205 West Wacker Drive, has been reserved for this display, which will consist of several hundred pieces of Allen-Bradley control equipment, ranging from their smallest photoelectric relay and push-button stations to their largest high-tension automatic starters. The complete line covers controllers for practically all industries and includes standard duty, water-tight, dust-tight, and explosion-proof equipment. The control circuits of the control devices on display will be connected to power feeders so the visitor can observe the operation of the equipment. The exhibit will be in charge of Eugene F. LeNoir, assisted by several members of the Allen-Bradley engineering staff, who, during the four weeks of the exhibit, will give frequent talks before groups of engineers and students.

Trade Literature

Transformers.—Bulletin 148, 24 pp. Describes transformers for instrument and metering service. Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

Splice Boxes.—Bulletin, 8 pp. Describes a new and comprehensive line of splice boxes which have been developed because of the increased popularity and possibilities of this type of cable joint. G & W Electric Specialty Company, 7780 Dante Avenue, Chicago, Ill.

Gearmotors.—Bulletin 20536, 4 pp. Describes Westinghouse "gearmotors," consisting of speed reducers combined with induction motors into single, self-contained units. Twenty reduction ratios of 1.12:1 to 10:1 are available for each motor speed and horsepower. Westinghouse Electric & Mfg. Co., East Pittsburgh, Penna.

Motors.—Bulletin H-1, 14 pp. Describes Star ball-bearing motors designed specifically for hoist duty, with and without built-in brakes. Star Electric Motor Company, Newark, N. J.

Illumination.—Bulletin 375-J, 52 pp. Comprises the Holophane "Datalog." This issue contains new developments on lighting equipment for 1932 and includes an engineering section and recommended standards of foot-candles illumination. Holophane Company, Inc., 342 Madison Avenue, New York.

Ground Tester.—Bulletin 1300, describes a new small, light weight, direct-reading instrument for measuring ground resistance. This instrument is mounted in a cast aluminum case and weighs 7½ pounds. James G. Biddle Company, 1211 Arch Street, Philadelphia, Penna.

Floodlighting.—Bulletin GEA-1505, 4 pp., Floodlighting for outdoor construction; Bulletin GEA-1506, 4 pp., Floodlighting monuments and memorials; Bulletin GEA-1507, 4 pp., Floodlighting for homes and estates; Bulletin GEA-1509, 4 pp., Illumination of parks. General Electric Company, Schenectady, N. Y.

Mechanical Stokers.—Catalog, 40 pp. A condensed catalog of mechanical stokers manufactured by fourteen different producers of such equipment. Included are brief but complete descriptions of the most prominent types of stokers. The descriptive matter is confined strictly to engineering data, permitting ready comparison of the various types. Stoker Manufacturers Association, Foot of Walker Street, Detroit, Mich.

Transformers.—Bulletin 3110. Describes a new constant current street lighting transformer. This transformer has a unique arrangement whereby both primary and secondary coils move through a small angle thus giving better regulation and a higher power factor. The new unit is represented as having many superior operating characteristics; quiet in operation, low in maintenance cost and has higher operating efficiencies. It is manufactured in all standard sizes from 3 to 30 kva. for both pole and subway use. Moloney Electric Company, 5390 Kingshighway-Bircher St., St. Louis, Mo.